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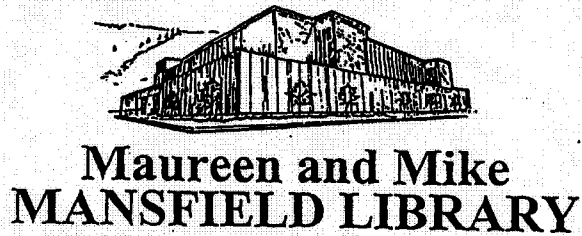
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CRYSTALIZED VERSUS FLUID INTELLIGENCE IN AMERICAN INDIAN
CHILDREN REFERRED TO DEVELOPMENTAL CLINICS:
AN EXAMINATION OF MULTIPLE MEASURES AND INDICATORS

by

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B.S., The University of Great Falls, 1996

M.A., The University of Montana, Missoula, 2000

presented in partial fulfillment of the requirements

for the degree of

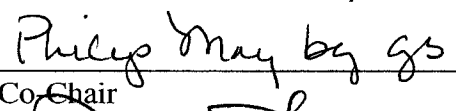
Doctor of Philosophy

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Crystallized versus Fluid Intelligence in American Indian Children Referred to Developmental Clinics: An Examination of Multiple Measures and Indicators (106 pp.)

Co-chairs: Gyda Swaney, PhD *gs*
Philip A. May, PhD *pm*

The issue of environmental versus constitutional contributions to children's intelligence has long been, and continues to be, of interest to both educators and psychologists. For Native American children there is no valid framework for arranging the available information on Native abilities, which will allow internal cultural diversity to be represented. A basic premise is that ethnic influences result in different kinds of intellectual skills. This premise can be translated into one question regarding the meaning of fluid and crystallized mental abilities among Native children. The purpose of this study was to investigate differences between crystallized intelligence and fluid intelligence in Plains Indian children from a sample referred for developmental clinics. By examination of these differences, it is possible to determine that native children may possess different attributes of intelligence from other American children that are being overlooked by not fully weighing the contribution of fluid intelligence.

Additionally, this investigation examined the contributions of maternal factors such as education and prenatal alcohol use and the effect on children's crystallized and fluid intelligence. Based on Catell's conceptualization of fluid and crystallized intelligence, it was hypothesized that mother's educational level would correlate positively with the child's crystallized abilities. Finally, this study sought to investigate the separate and combined multivariate relationships between children who are diagnosed with FAS and environmental factors such as mother's age at birth of the child. Numerous researchers have found marked intellectual deficits in children exposed to alcohol prenatally. Relatively little is known, however, of the individual variability of intellectual performance on children with FAS. Therefore, this study sought to identify patterns of intellectual performance of alcohol-exposed children by using a psychometrically more refined distinction of abilities: fluid versus crystallized intelligence.

DEDICATION

First and foremost, I thank Creator. It is with great honor that I dedicate this manuscript to my family. Throughout my life they taught me to persevere in the face of adversity and continued to provide support for me in times of greatest need. To my grand kids and children, you waited and believed, this is for you and especially to my husband, who was always there even when I cried and screamed. I also dedicate this to my brother, Itsy, who died waiting for me to finish, here it is brother...it's done.

Acknowledgements

My deepest gratitude extends to my dissertation advisor, Phil May. He extended his support and guidance above and beyond the bounds of expectation. His mentorship in research will carry me far. I would also like to thank my co-Chair, Gyda Swaney, for her careful support and model as an American Indian woman psychologist.

I would also like to thank Tassy Parker and Bonnie Duran for their assistance and encouragement in finishing this dissertation and Joey Jiang for his statistical expertise, without which I would still be contemplating piles of data.

Thank you to my committee members at the University of Montana: Chris Fiore, Ph.D., David Schuldberg, Ph.D., Paul Silverman, Ph.D., Jennifer Waltz, Ph.D., and Patrick Weaselhead, Ed.D . You have served well.

I could have not attempted and completed this study with out the generosity of CASAA at the University of New Mexico. In particular, the FASER study, which Dr. May opened the data base for my dissertation. The data provided a window into the multiple layers of American Indian children's lives with a richness that would not have been possible for me to gather independently at this time.

Finally, I wish to thank my husband. His words of love, encouragement, AKAKIMA (keep going in Blackfeet) have provided me with the will and strength to survive.

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Crystallized versus Fluid Intelligence in American Indian Children Referred to Developmental Clinics: An Examination of Multiple Measures and Indicators

Chapter One

Background and Significance of the Study

Simplified to the elements of a dichotomy, there are two historically important constructs for the assessment and study of the structure of broad human cognitive abilities. While there have been other partitions of facets of intelligence (Gardner, 1983; Guilford, 1980), fluid and crystallized intelligence have historically offered an approach for the investigation of possible differences in cognitive abilities among groups. Moreover, Catell's (1963, 1971) and Horn and Catell's (1966) theory of fluid and crystallized intelligence provides an impetus for delineating possible differences in ability patterns among and within ethnic groups.

Testing the assumption "that all children's cognitive abilities are the same is untenable and intelligence actually varies across ethnic groups" (Banks, 1972, p.269) continues to be an interest to both educators and psychologists. Studies have examined the relationships between maternal intelligence and child intelligence. Specifically, much research examines biological maternal intelligence versus an adopted child's intelligence (Fulker, Defries, & Plomin, 1989; Plomin & DeFries, 1985), the effect of environmental conditions on children's intelligence (Haywood & Switzky, 1986; Yeates, MacPhee, Campbell, & Ramey, 1983), effects of family size (Lancer & Rim, 1984), and racial differences in inherited versus acquired abilities (Jensen, 1980). This proposed study will contribute to this body of literature and investigate fluid and crystallized intelligence in Plains Indian children. Furthermore, this study will investigate separate and combined

multivariate relationships between maternal crystallized abilities, several environmental variables, and children's fluid and crystallized intelligence.

A Unified Theory of Intelligence

Spearman (1927) described one model of cognitive ability which was essentially a single-factor model. Spearman's single factor model (the factor was known as "g") stated that other factors of intelligence are subsumed under "g," with the "g" factor representing a general mental energy in which complicated mental activities accounted for the greatest amount of "g".

Cattell (1963, 1971) and Horn and Cattell (1966) have presented a theory of cognitive functioning that they assert is useful in the examination of mental abilities, and relationships between ability and school achievement, for different ethnic groups. Cattell's theory of fluid and crystallized mental abilities is based on the differential characteristics of two general types of intelligence: crystallized and fluid. According to Cattell (1992), Spearman's "g" really covers two distinct general structures: fluid (Gf) and crystallized (Gc) intelligence.

Fluid Intelligence

Fluid intelligence (Gf), according to Cattell (1963, 1992), is primarily related to general genetic factors and physiological-neurological functioning, and it is manifested in relation to perception and performance in new situations. The nature and definition of fluid intelligence are that "it is a capacity for insight into complex relations accounting for that part of the test variance which seems independent of the particular sensory or cultural environments in which the tests are expressed. The theory is that this is a capacity for relation education and is neurologically determined" (p. 365).

Fluid intelligence is measured most purely when the task materials are culturally fair, i.e. the cultural bias of the task materials has been minimized. The Gf is manifested in tasks of reasoning, such as cognition of figural relations and figural classes, cognition regarding semantic relations, and general and formal reasoning. It is characterized by concept formation and the abstraction process and is manifested through reasoning in the immediate situation when tasks are cognitively complex. It is often claimed that Gf is the most important and quintessential aspect of intelligence. In summary, fluid ability is a general intelligence factor that consists of abstract thinking abilities and problem solving in the immediate situation.

Crystallized Intelligence

Crystallized intelligence is also a general intelligence factor but, unlike fluid intelligence, it is more dependent on cultural influences (Horn & Cattell, 1966). It has been characterized by awareness of concepts which were previously learned, and relations among these previously learned concepts. Cattell (1992) views crystallized intelligence as composed of the primary abilities, such as verbal, numerical, spatial, and mechanical aptitudes. Crystallized intelligence consists of those cognitive abilities in which skilled judgments are a part of one's history. Horn (1985) defined crystallized intelligences as an indication of the extent to which one has attained the knowledge of a culture. Crystallized intelligence often involves established cognitive functions related to achievement and includes those abilities influenced by formal and informal education (Valencia & Suzuki, 2001). Jensen (1998) also discussed crystallized intelligence as "consolidated knowledge" that was "most highly loaded in tests based in scholastic knowledge and cultural content where the relation-education demands are fairly simple"

(p.123). In summary, crystallized intelligence is a general intelligence factor that consists of ability to reason through the use of previously attained concepts.

Comparing the Two Forms of Intelligence

A summary comparison of fluid and crystallized intelligence follows. Fluid intelligence is a label for perceiving an unfamiliar configuration and rearranging it to satisfy some requirement (an adaptive process). It is convenient to think of fluid intelligence as a single construct, but it is complex and not unitary (Cronbach, 1984), because several subordinate processes must function at once to produce efficient performance. In contrast, crystallized intelligence involves the demonstrated speed of computation, recall of word meanings, and other familiar tasks. The intercorrelations among crystallized abilities derive from the shared educational experience to which most persons are exposed. According to Undheim (1990), Gc develops out of Gf; when persons with equal Gf differ on Gc, the explanation is purported to lie either with the extent of their education or in the effort they put into their education.

Introduction to Gf-Gc theory

There is a growing recognition of the importance of scientific theories and research studies on the structure and function of broad human cognitive abilities. Controversies over the well-known acronym "IQ" are in part fundamental scientific debates about the unitary nature of intellectual abilities (e.g. "g" theory; Carroll, 1993, 1997; Jensen, 1980, 1998; Mackintosh, 1998) in contrast to a multiple abilities perspective (Cattell, 1998; Horn & Noll, 1998).

Raymond Cattell (1963) was first to discuss the two distinguishable types of tests for general intelligence. He described some tests as requiring mental work on the spot

with largely unfamiliar materials and problems, which called for what he called, “fluid intelligence”. Other tests required knowledge which he termed “crystallized intelligence”. His research indicated that tests of fluid and crystallized intelligence correlated at around .70. Gf-Gc theory provides a model for conceiving and classifying cognitive abilities.

Other Models of Intelligence

H.J. Eysenck (1982) presented a theory of intelligence that included three types: Intelligence A: Elementary Information Processing (fluid intelligence being a part of this); Intelligence B: Acquired Problem-Solving Skills (includes crystallized intelligence); and Intelligence C: Artifact of Averaging Unlike Abilities (includes IQ). He stated that Intelligence A, including fluid intelligence, is a genetically determined, physiologically mediated form of intelligence and can be measured by electroencephalograms (EEGs) and reaction times (RTs) on simple cognitive tests. Intelligence C (reified abstraction, analytic intelligence), however, is best measured by psychometric tests.

John Horn (1982), along with Cattell, developed a theory of intelligence that specified the same two broad factors, fluid abilities (Gf) and crystallized abilities (Gc), and he presented evidence that multiple factor research indicated that approximately 80% of intellectual ability could be measured and predicted in terms of as few as 30 basic processes. These authors further suggested the most of the variation represented in these primary processes could be organized in terms of as a few as eight or nine-second-order abilities. The original presentation of Cattell in 1941 presented the two-factor theory of

intelligence, and this has been expanded since that time; the Gf-Gc theory is the basis for multiple intelligences theories.

Alternative theories of multiple intelligence are proposed by Thurstone (1938), Guilford (1967, 1977, 1982), and Gardner (1983). Thurstone (1938) proposed a theory of intelligence that did not include “g” but rather emphasized a series of distinct multiple factors. This theory identified eight Primary Mental Abilities (PMA’s): Verbal, number, perceptual, speed, rote memory, inductive reasoning, deductive reasoning, word fluency, and space or visualization. While Thurstone’s initial model emphasized specific abilities, it did not disprove the existence of “g”. In fact, Thurstone modified his model by conceding the existence of a higher-order general factor similar to Spearman’s “g” after Eysenck (1939) reanalyzed Thurstone’s data and demonstrated the extraction of a g was possible in addition to several group factors (Thurstone & Thurstone, 1941).

Guilford (1967) suggested three dimensions by which all ability factors can be represented: operation, content, and product. The most recent modifications of this theory (Guilford, 1977, 1982) include five operations, five contents, and six products, resulting in 150 ability factors. Guilford’s Structure-of-Intellect theory has not been empirically validated, but it has been suggested that at least construct has been validated in a factor analysis and that many of the factors have alluded to the existence of higher-order factors (Guilford & Heopfner, 1971).

Gardner (1983) defined intelligence as the ability to solve problems or to create products that are valued within one or more cultural settings. Also, he specified seven intelligences or competencies. linguistic, musical, logical-mathematical, spatial, bodily-kinesthetic, intrapersonal, and interpersonal. Each intelligence or competence has a

developmental trajectory relatively independent of the others. Most recently, Gardner (1999) introduced three possible new intelligences: naturalist intelligence, spiritual intelligence, and existential intelligence. He further refined his definition of intelligence as a “biographical potential to process information that can be activated in a cultural setting to solve problems or create products that are of value in a culture” (pp. 38-34).

Factor analysis of psychometric approaches to assessing cognitive abilities consistently yields a structure interpretable in a manner consistent with the models of Spearman, Cattell, and Eysenck. Carroll (1993) extensively reviewed and compiled more than 460 factor-analytic studies of cognitive abilities. He derived the global three-stratum model of intelligence as defined by the psychometric measurement of abilities. Although, Carroll suggests that each stratum varies from study to study, and that the hierarchical nature of the resulting structure and the prevalence of fluid, crystallized, and general intelligence factors are robust.

Thus, the notion of multiple intelligences emerged from the work on the theory of fluid and crystallized intelligence (Cattell, 1971, 1987; Horn & Cattell, 1982; Horn & Cattell, 1966). This has gained a great deal of credibility through recent empirical research, and Gf-Gc theory is now used in a variety of commercial batteries (e.g., the Woodcock Johnson-Revised, McGrew, Woodcock & Johnson, 1989; McArdle & Woodcock, 1997). This broadened view of multiple intelligences represents three explicit predictions about the complex nature of human cognitive abilities first considered by Cattell (1941, 1971).

The first prediction of the Gf-Gc theory posits that a single general factor such as Spearman’s “g” will not account for the patterns of variation seen among multiple

abilities. Cattell further presented that one broad factor, Gc, was thought to represent acculturated knowledge, and the other broad factor, Gf, was thought to represent reasoning and thinking in novel situations (McArdle, Hamagami, Meredith, & Bradway, 2000).

Repeated examination using independent sets of data have led to broad support for the overall theory. One recent meta-analysis, previously mentioned, of almost 500 cognitive research studies (Carroll, 1993, 1998) showed a remarkable set of similarities among the theories used by most researchers in this area (Flanagan & McGrew, 1996; Hakistian & Cattell, 1978; Horn, 1988). Critiques of this two-factor structural theory came from the implicit acceptance of a single g factor with little or no explicit test of the Gf-Gc theories (Jensen, 1980, 1998).

The second of the predictions of the Gf-Gc theory posits that Gc, together with Gf, will rise over the early phases of the life span. But in early adulthood there is further growth of Gc, but the Gf levels off, declining with adulthood and aging. This has been found to be accurate in a wide range of cross-sectional and longitudinal data sets (Baltes & Mayer, 1999; Donaldson & Horn, 1992; Horn & Cattell, 1967; Horn & Noll, 1998; Lindenberger & Baltes, 1997; McArdle & Prescott, 1992; McArdle, Prescott, Hamagami, & Horn, 1998; Schaie, 1996). These structural and age-curve predictions of Gf-Gc theory have included additional abilities such as memory, sensory, and perceptual constructs. However, there is also evidence that some capabilities thought to indicate intelligence do not decline, or do not decline markedly until very old age such as those indicating breadth and depth of knowledge, referred to as crystallized knowledge and those of association retrieval from the store of knowledge (Masunga & Horn, 2001).

A third set of predictions was based on the sequence of relationships among abilities over time. In early childhood the asset of Gf, coupled with other lower order factors in the context of education setting, was thought to lead to individual differences in the development of Gc (McArdle, Hamagami, Meredith, & Bradway, 2000). Evidence supporting this dynamic prediction of Gf-Gc theory is still equivocal. A few recent studies have examined aspects of these hypotheses (Embretson, 1991; McArdle & Hamagami, 1996; Salthouse, 1991), but the results are not substantiated. Other evidence is based on related dynamic theories, including the cognitive process model, such as the “triarchic theory” of Sternberg (1985); resource processing models (Salthouse, 1991); developments in the measurements of dynamic traits (Embretson, 1996); and the complexity-effect model (Stankov, 1994). Some recent life-span concepts based on dynamic adaptation have recently been described in theory that focuses on the importance of the measurement of selectivity, optimization, compensation, and wisdom (Baltes & Smith, 1997). Gf-Gc theory is often the base of theoretical dynamic models such as theories of personality, motivation, and “emotional” aspects of intelligence (Ackerman, 1992; Goleman, 1995, Davies, Stankov, & Roberts, 1998).

Cattell (1971, p. 290-293) suggested that small but real differences in mean fluid ability exist among various racial groups. Use of the unified theory of fluid and crystallized intelligence should make it possible to examine patterns of abilities specific to an ethnic group (Miller, 1972). Gf-Gc theory could also make it possible to examine relationships of abilities to achievement for different ethnic groups and to detect possible differences among these causal relationships. The theory offers alternatives for explaining operations and processes that reflect intelligence. Specifically and important

to this research, is the usefulness of the theory to examine patterns of abilities specific to an ethnic group. The theory should also make possible the examination of relationships of abilities to achievement for different ethnic groups and detection of differences among these groups. In support of this, Horn and Cattell (1966) suggested that there were many cognitive tasks which allow an individual to use either fluid intelligence or crystallized intelligence to arrive at the correct answer to a problem. It remains to be investigated whether individual and group differences among these abilities exist in different ethnic groups, and also whether there are differences in patterns of relationships between mental abilities and achievement in different ethnic groups.

Gf-Gc Research

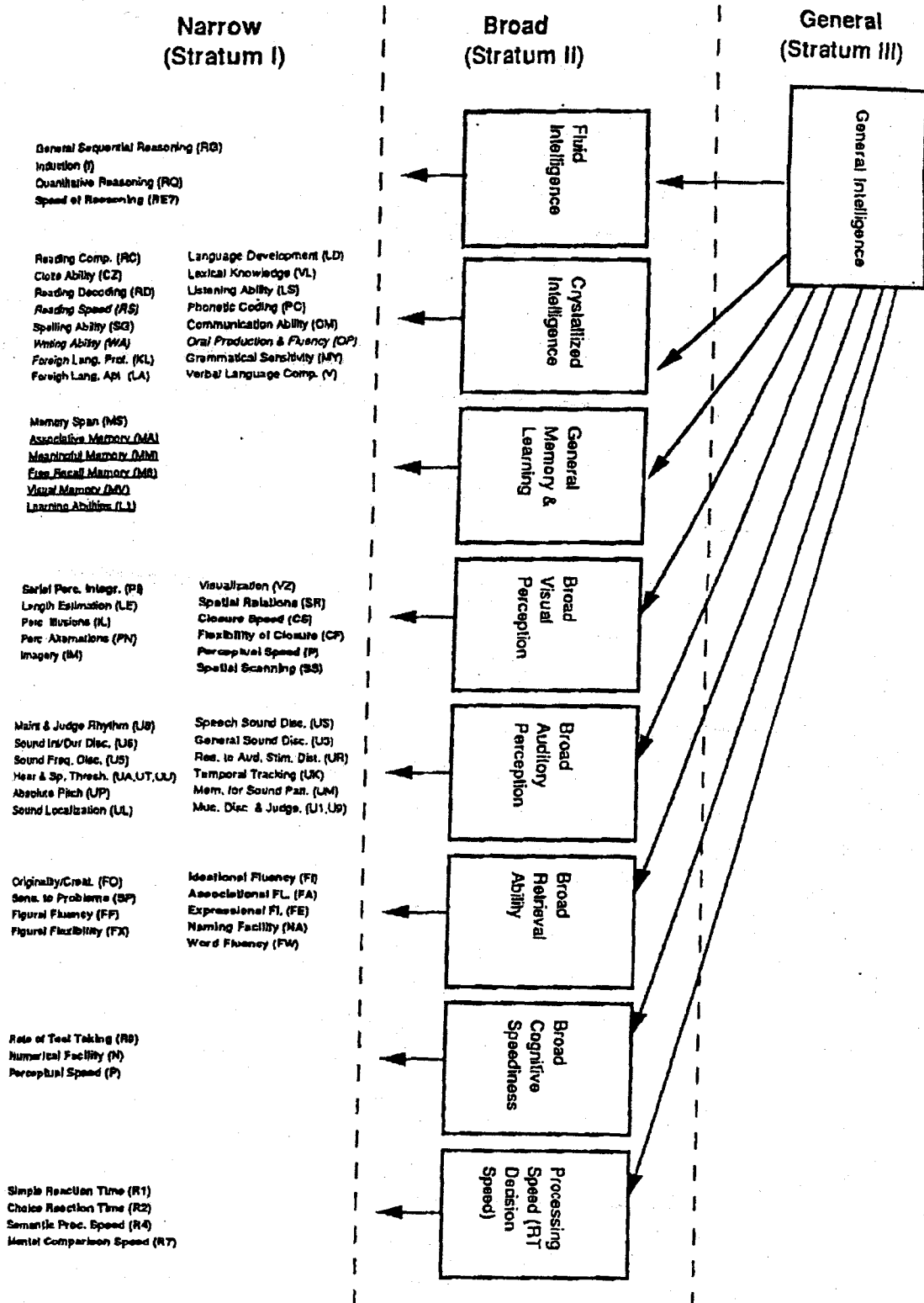
Studies of the structure of intelligence are well-established, and yet investigations of the structure of intelligence in general have been reported to be characterized by design problems, psychometric limitations, and limitation in scope (Bracken, Howell, & Crain, 1993). However, the structure of intelligence in minority populations and children is less well investigated. This literature review will present both bodies of research in an attempt to fully understand and clarify the unique contributions of research on crystallized and fluid intelligence.

The notion that Spearman's "g" really covers two distinct general structures was presented at an APA meeting in 1940 (Cattell, 1992). Cattell presented behavioral evidence for two factors, and Hebb independently presented physiological evidence which fit the behavioral analysis of two distinct factors involved in intelligence (Cattell, 1992). This two factor model was extensively developed in the 1960's by Horn and Cattell (1966, 1967). Horn and his colleagues have stated in many different studies that

fluid intelligence is defined by flexibility, analytic ability, and adaptability when confronting novel, problem-solving situations (Cattell & Horn, 1978; Horn, 1970, 1978, 1991; Horn & Cattell, 1966, Horn & Hofer, 1992). These same studies have confirmed that crystallized intelligence relates to acquired skills and knowledge that are strongly dependent on exposure to culture and education (Kaufman, 1994; Kaufman & Kaufman, 1993; Sattler, 1992).

The Gf-Gc model has been expanded to include other abilities. A three-stratum model of intelligence was later introduced by Carroll (1993). Carroll's model is defined as follows: Stratum III is defined as general intelligence, theoretically similar to the aforementioned model of Spearman's "g". Stratum II is comprised of eight broadly defined capabilities, such as holding and accessing information in short and long term memory. Also in Stratum II is crystallized intelligence (Gc), fluid intelligence (Gf), and visual spatial reasoning ability (Gv). These second level abilities are correlated highly (Carroll, 1993) and provide evidence for the third level of general intelligence or Spearman's "g". Carroll (1993) further noted that Stratum I is composed of 69 narrow abilities, all of which are subsumed by Stratum II abilities (see Figure 1). Ongoing debate exists among researchers about whether the concept of g is superfluous (Horn & Noll, 1998); Jensen (1998) argues that it is real and central to the concept of intelligence, and Gustafsson (1988, 1999) has argued that g and Gf are inseparable. Various aspects of the three-stratum model have been challenged on theoretical grounds (Carroll, 1993; Cole & Randall, 2003; Horn, 1991; McFall & Townsend, 1998). This continues to be the basis for current research.

Figure 1. The three-stratum structure of cognitive abilities. From Carroll (1993). Copyright 1993 by Cambridge University Press. Reproduced by permission.



Woodcock (1990) investigated the Gf-Gc theory using nine data sets drawn from the 1977 and 1989 norming and concurrent validity studies of the Woodcock-Johnson Psycho-Educational Battery-Revised (WJ-R; Woodcock, R., & Johnson, M., 1989). In the concurrent studies, the WJ-R was administered in conjunction with the Kaufman Assessment Battery for Children (K-ABC; Kaufman & Kaufman, 1983), the Stanford-Binet Fourth Edition (SB-4; Thorndike, Hagen, & Sattler, 1985), the Wechsler Intelligence Scale for Children-Revised (WISC-R; Wechsler, 1974), and the Wechsler Adult Intelligence Scale-Revised (WAIS-R; Wechsler, 1981). Exploratory and confirmatory factor analyses including a total of 68 variables provided support for an eight factor Gf-Gc model. The factors identified include Comprehension-Knowledge (Gc), Fluid Reasoning (Gf), Visual Processing (Gv), Auditory Processing (Ga), Processing Speed (Gs), Short-Term Memory (Gsm), Long-Term Retrieval (Glr), and Quantitative Ability (Gq). Interestingly, each of the batteries is based upon a different mix of factors. These factors are listed and described in Table 1. For example in the K-ABC, there appear to be five factors (Gsm, Gs, Gv, Gf, and Gq) contributing to the composite score. In the SB-4 there also appear to be five factors contributing to the composite score (Gsm, Gv, Gc, Gf, and Gq). For the WJ-R Broad Cognitive Ability score, there are two subtests measuring each of seven factors (Gsm, Gs, Gv, Gf, Glr, Ga, and Gc; McGhee, 1991). Factor analytic studies lend support for the Gf-Gc theory, further present broad measures of the structure of intelligence, and are fast becoming standard practice in the field of psychometry as evidenced by the factor scores available for the WJ-R, SB-4, K-ABC, and the Wechsler Intelligence Scales (McGhee, 1991).

Table 1

Description of Gf-Gc Factors

Factor Name	Symbol	Description
Comprehension-Knowledge	Gc	A measure of the breadth and depth of an individual Knowledge, experience, and sophistication based upon previously learned procedures.
Fluid Reasoning	Gf	A measure of the capability to reason in novel situations. Demonstrated through deductive, inductive, conjunctive, disjunctive, and other forms of reasoning, drawing inferences from relationships, and comprehending implications. Tasks intended to measure Gf should not depend heavily on previously acquired knowledge. Gf is best measured with tasks that are novel.
Visual Processing	Gv	A measure of perceiving, thinking with and integrating visual patterns and spatial configurations. Gv tasks include recognizing rotations and reversals of figures, finding hidden figures, identifying incomplete or distorted figures, and comprehending spatial configurations.

Table 1 (continued)

Factor Name	Symbol	Description
Auditory Processing	Ga	A measure of the ability to comprehend patterns among auditory stimuli.
Processing Speed	Gs	A measure of the ability to work quickly, particularly when measured under pressure to maintain focused attention. Examples of Gs include speed of scanning, comparison, printing, or writing.
Short-Term Memory	Gsm	A measure of the ability to store information in the immediate situation and then retrieve it within a few seconds.
Long-Term Retrieval	Glr	A measure of the ability to retrieve information through association, after time.
Quantitative Ability	Gq	A measure of the capability to comprehend quantitative concepts and relationships and to manipulate numerical symbols.

The Gf-Gc theory continues to be the core of intelligence research even though studies have expanded the facets of intelligence to include other abilities. Authors of various tests have used multiple interpretations of this core theory; an example is the development of the WJ-R, which addresses Horn's expanded model of crystallized and

fluid intelligence and the WJ-III (Woodcock, McGrew, & Mather, 2001), which was developed on Carroll's Three-Stratum theory. Kaufman and Kaufman (1993), however, developed the Kaufman Adolescent and Adult Intelligence Test (KAIT) within the fluid-crystallized dichotomy, as they believed that this was a more clinically relevant interpretation of the Gf-Gc theory. Despite criticisms of the theory (Guilford, 1980), the theory has stable evidence to support the general construct and has been used to explain quite well the decline of intelligence with aging and improvement techniques among the elderly (Baltes, Dittman-Kohli, & Kliegl, 1986; Baltes, & Willis, 1982; Dixon, Kramer & Baltes, 1985; Kaufman & Horn, 1996; Kausler, 1982; Schaie & Willis, 1986).

Aging Studies of Gf-Gc Theory

Aging studies, which represent one particular approach to the evaluation of crystallized intelligence and fluid intelligence, now represent a large body of literature and research. Studies by Horn (1978, 1989) claimed that crystallized abilities improve and are maintained during the aging process, while fluid abilities peak in late adolescence and then decline rapidly as individuals go from early adulthood to old age. Masunga and Horn (2000) presented the results from a study of 263 male subjects at 48 levels of expertise in the ability to play the game of GO, a form of expertise that clearly involves a high level of intellectual functioning. The men ranged from 18 to 78 years of age. This study concluded that the theory of Gf-Gc needs to be revised and to take into account the continued development of intelligence throughout adulthood. The extended theory of Gf-Gc is based on evidence that Gf, short-term apprehension and retrieval (SAR), and cognitive speed (Gs) decline with age over adulthood. However results from a number of

aging studies suggest that within the domains of expertise, high levels of reasoning, feats of memory, and speeded thinking (which are similar to Gf) are displayed by older adults (Ericsson, 1996; Ericsson & Charness, 1994; Ericsson & Kintch, 1995; Ericsson & Lehmann, 1996; Gobet & Simon, 1996; Hershey, Walsh, Read, & Chulef, 1990; Horn & Noll, 1998; Kramkpe & Ericsson, 1996; Morrow & Leirer, 1997; Morrow, Leirer, Altieri, & Fitzsimmons, 1994; Walsh & Hershey, 1993).

These studies suggest that the feats of memory, problem solving, and reasoning displayed by experts, in playing chess for example, are advanced expressions of human intelligence. The level of resolving complexities in expert chess performance is said to be every bit as high as the level of resolving complexities in matrices that are used to measure Gf (Masunga & Horn, 2000). Masunga and Horn found in their study that that mean levels of expertise and cognitive speed are notably different for groups at different levels of expertise.

Additionally this research has presented factor analytic evidence of expertise in the abilities of deductive reasoning and wide-span memory that are independent of Gf, short term working memory, and cognitive speed (Gs). These results support the theory that distinct reasoning and memory abilities are accumulated in adulthood through a process of acquiring expertise, and this continues beyond the development of Gf and short-term working memory. The researchers suggest that it appears worthwhile to recognize expertise reasoning and expertise working memory as dimensions of intelligence that are not stagnant, like Gc, and do not decline as suggested by Gf, but improve with advancing age in a person's domains of expertise. This finding is consistent with the hypothesis that long-term working memory is built up during the

course of developing high levels of expertise. The results also suggest that a form of expertise deductive reasoning, utilizing expertise working memory and incorporating large stores of knowledge, is distinct from Gf.

In other research, longitudinal data from the WAIS were evaluated using structural equation models to investigate the dynamic theory of fluid and crystallized intelligence (McArdle et al., 2000). This research used WAIS data from the Bradway-McArdle Longitudinal Study (Bradway, 1944; Bradway & Thompson, 1962; Bradway, Thompson, & Cravens, 1958; Kangas & Bradway, 1971) and from the Berkeley Growth Study ; (Bayley, 1957; Eichom, Clausen, Haan, Honzik, & Mussen, 1981). These two data sets were comprised of individuals measured at three different age ranges, beginning as children, with the average adult age of 30 and 42, and with follow-ups at 50 and 60 depending on the study cohort. Results of the analyses provide support for the hypothesis of “general memory loss” with age, and the hypothesis of “general slowing” with age. In essence, the results suggest that some part of the individual differences in the declines in board knowledge (Gc) are encouraged by lower levels or resisted by higher levels of fluid reasoning (Gf). This study also indicated that the Gf-Gc distinction remains evident in the adult part of the life span. And, along with other findings, the researchers found that other ability variables (i.e. vocabulary performance, digit span performance, and block design performance) may act as cofactors in these relationships and that speed (Gs) and short term memory functions (Gsm) were critical components to cognitive aging. One important finding of this study was that the concept of Spearman’s “g” did not effectively account for multivariate changes over the life span. The single

“g”factor represents a simplistic view of the more complex sequential dynamics of the cognitive system (McArdle, et al., 2000).

Other aging studies have focused on the speed dimension of intelligence. For example, Botwinick (1977) attributed the recurrent finding of maintenance of Verbal IQ (often thought of as crystallized), and the large decline of Performance IQ (often thought of as fluid) across the life span resulting from changes in the speed dimension. Botwinick further presented evidence that maintenance on non-speeded tasks and a decline on speeded tasks could be attributed to aging. Supporting research has attributed the decline on speeded tasks primarily to diminished motor coordination, and, since visual motor coordination is essential to obtaining a high Performance IQ, the recurrent finding regarding the Verbal IQ / Performance IQ pattern has been given the name “classic intellectual aging pattern” (Botwinick, 1977). In fact, Digit Symbol, which relies the most heavily on coordination, consistently produces the steepest age-related declines on the WAIS or WAIS-R (McLean, Kaufman, & Reynolds, 1988).

There are also numerous arguments that support a fluid-crystallized interpretation of the classic intellectual aging pattern, rather than relying on the speed, or diminishing coordination explanation (Kaufman, 1990, pp. 222-230). In addition, on multiple empirical analyses of the WAIS and WAIS-R, it was found that Gf was included in all of the Performance subtests except Digit Symbol, and Gc was composed of the four Verbal subtests commonly associated with Wechsler’s Verbal Comprehension factor (Horn, 1985; Horn & McArdle, 1980). Furthermore, it has been suggested that the Performance subtests include Broad Visual Intelligence (Gv), and it is hard to distinguish Gv from Gf if visual tests can be performed by reasoning (Horn, 1991). The Kaufman Brief

Intelligence Test (K-BIT) Vocabulary and Matrices subtests have been suggested to provide seemingly pure measures of crystallized and fluid constructs, respectively (Wang & Kaufman, 1993). Vocabulary is a measure of word knowledge and verbal problem solving, a prototypical Gc subtest. Matrices, on the other hand, emphasize reasoning rather than spatial visualizations, a common exemplar of a Gf subtest (Horn, 1989, 1991). The K-BIT abstract Matrices items are akin to Raven's Matrices Test (Raven, Court, & Raven, 1983). In a study of 500 individuals ages 20 to 90, the KBIT was used as a measure of both fluid and crystallized intelligence (Wang & Kaufman, 1993). Findings indicate and confirmed the existence of the classical intellectual aging pattern. Vocabulary performance peaked in the 40s, both with and without adjustment for education, and mean scores dropped substantially after age 69. Matrices scores remained fairly constant between ages 20 to 38, with scores tailing off after age 39. The speeded-nonspeeded hypothesis cannot explain the results of this investigation, as time tasks are not a factor in the K-BIT. However, this study does provide further support for the fluid-crystallized model of intelligence.

Along this vein, researchers investigated adult age differences in the accuracy, or realism of subjects' confidence judgments on the correctness of their answers to test items (Crawford & Stankov, 1996). Tests of fluid and crystallized intelligence, short-term memory, and perceptual discrimination were given to 97 subjects between the ages of 17 and 85 years. A trend was constant across the fluid intelligence, crystallized intelligence, and visual discrimination tasks: Older persons performed worse, better, and about the same respectively, on these three types of tests, following the typical age

pattern of fluid intelligence and short-term memory declining with age; crystallized intelligence improved with age.

In related research on “wisdom”, Baltes and Staudinger (2000) conducted a study where a large number of relevant measures were considered as predictors of wisdom performance. Wisdom as defined by Baltes and Staudinger is “an expert knowledge system concerning the fundamental pragmatics of life” (p.122). Specifically a total of 33 psychometric indicators that were based on 14 tests of intelligence were administered, with fluid and crystallized intelligence being the marker subscales. The findings indicate that wisdom-related knowledge and judgment are not simply another variant of intelligence or personality, as measured by working memory in samples that extend across the entire adult range and how participants would react in a variety of cultural situations. Rather, wisdom implies a coordinated configuration of multiple attributes, including crystallized and fluid intelligence and knowledge associated with specific life experiences. There is no question in this study about whether the participants understood the problem presented to them, so individual differences in verbal comprehension were not the issue. Individual differences were driven by a person’s knowledge of what to do in the situation. Thus there was no decline in “wisdom” across the life span.

The extant literature provides good evidence of the relation of aging to fluid and crystallized intelligence. However, studies on fluid and crystallized with young children, and specifically with Native children, is limited.

Other Previous Research on Gf-Gc

Other research has focused specifically on crystallized intelligence, crystallized intelligence and achievement, and tests of attentional and perceptual-motor ability in

relation to “g”. These studies will be presented in order for a complete and thorough examination of the Gf-Gc theory.

Ackerman, Beier, and Bowen (2000) attempted to reconcile two historically important tools for the assessment of intelligence and the prediction of academic achievement. They used the cloze tests and completion test performance in accounting for both measures of crystallized intelligence (Gc) and four scales of knowledge (biology, U.S. History, U.S. literature, and technology) which tap recognition and declarative knowledge, with extant theories of verbal-crystallized knowledge aspects of adult abilities. A study of 167 adults ranging in age from 18 to 69 explored the complex abilities that make up the verbal-educational-knowledge component of adult intelligence using a completion test and a cloze test. Subjects were administered a completion test, in which they were read test passages and then are instructed to fill in missing words, and a cloze test which involves comprehension such as general language facility, specific knowledge, and vocabulary relevant to the materials at hand. Completion tests differed from cloze tests in their administration. Specifically, participants were instructed to listen to the passage read in its entirety, without looking at the completion test form. Afterwards they were instructed to fill in as many of the missing words as possible. Both measures are reported to be good indicators of crystallized intelligence. Cloze tests involve leaving the first and last sentences of the passage intact. Every fifth word is deleted starting with the second sentence. A knowledge test, developed mainly with content from the College Level Examination Program (CLEP) and Advanced Placement tests, was administered to tap the diverse domains of knowledge that people presumably develop and maintain over the adult life span (Ackerman, 1996). All three tests: the

cloze test, the completion test, and the CLEP have historically been used to measure crystallized intelligence. Results indicated that the completion tests accounted for all of the variance in Gc and in knowledge that the cloze tests accounted for, and resulted in incremental predicative validity of CLEP results for both domains. In addition, completion and cloze tests were found to have a suppressor effect on the relationship between Gc and age, in that removing the influence of individual differences on these tests increased the positive association between Gc and age. Results indicated that the cloze and completion tests can be a useful addition to the assessment of broad crystallized abilities, and these both appear to measure the same thing. This study suggested that abstract reasoning may not be as useful in predicting learning and performance as the completion test.

Correlations between tests of psychometric “g” and tests of attentional and perceptual-motor abilities have also been evaluated (te Nijenhuis & van der Flier, 2002). Test scores of 584 applicants for jobs at Dutch railways and bus companies were used. Findings indicated fluid and crystallized intelligence accounted for almost 54% of the variance in the tests, while broad visual perception accounted for 11%, general attentional-speed and general perceptual-motor ability accounted for 11 and 4 percent, respectively.

Similar research used the Armed Services Vocational Aptitude Battery (ASVAB), which is administered to over 1 million participants in the United States each year. Researchers examined the factor structure of the ASVAB and included several tests to measure Gf/Gc in the experimental design (Roberts, Goff, Anjoul, Kyllonen, Pallier, & Stankov, 2000). Factor analysis of two studies ($n = 349$, $n = 6,751$) suggested that the

ASVAB primarily measures acculturated learning or Gc, and the authors recommended that the military's assessment needs to be revised to include additional broad cognitive ability factors, particularly fluid intelligence and learning and memory constructs.

Gf-Gc Research with Children

In one of the few research endeavors directed at substantiating the fluid and crystallized intelligence distinction with children, Klauer, Phye, and Willmes (2002) investigated the breadth of training on inductive reasoning in children. Inductive reasoning is usually compared to deductive reasoning, in that inductive means establishing rules and deduction means applying rules (Klauer et al., 2002). Thus, inductive reasoning enables the detection of regularities, rules, or generalizations. This is one way in which children structure their world. They hypothesized that inductive reasoning, which is typically a marker of fluid intelligence, could be influenced by training. The investigators trained children of six classes to apply a strategy to reason inductively while the children of the remaining six classes continued their regular classroom activities. They utilized two tests of fluid intelligence, German versions of Cattell's Culture Fair Test (CFT 1; Weiss & Osterland, 1980) and Raven's Coloured Progressive Matrices (Schmidtke, Schaller, & Becker, 1980). They selected a vocabulary test to measure crystallized intelligence. Their findings indicated that inductive training had a strong positive impact on the latent dependant variable, fluid intelligence, but little impact on its counterpart, crystallized intelligence. They contend that training can foster processes and competencies that are subsumed under the concept of fluid intelligence. An important implication is that training students to reason inductively should also improve learning in academic settings.

Similarly, Langdon, Rosenblatt, and Mellanby (1998) evaluated the poor verbal skills of poor readers.

The researchers suggested that:

The distinction between fluid and crystallized intelligence is crucial to any examination of the link between discrepantly poor verbal skills and poor reading. The importance stems from the fact that even the reading aloud of single words is a learned skill, and therefore part of crystallized intelligence. Furthermore, since reading is an important mechanism for acquiring facts and information, it relates directly to the acquisition of crystallized intelligence. Thus poor reading could significantly disable performance on conventional reasoning tests (p. 177).

Subjects were 170 students with a mean age of 14.58 years and were administered a test battery which was selected for reportedly measuring fluid and crystallized significance. Findings indicated that children who had poor reading skills had relatively poor verbal fluid intelligence, which had led to problems in learning to read and a resulting reduced exposure to print.

Gustafsson and Undheim (1992) researched the stability of fluid intelligence and crystallized intelligence on children between the ages of 12 and 15 years of age. A large test battery was administered to a sample of 1,224 students in the 6th grade (about 12 years old). Subsets of the subjects were followed up in the 8th and 9th grades with a reduced version of the test battery being administered again. Measures of cognitive ability were mental folding, embedded figures, and card rotations which are measures of Gv. Measures of Gf were Raven Progressive Matrices, letter grouping, number series.

Opposites, a test that measures verbal comprehension, was considered to be a measure of Gc.

Findings indicate that general intelligence accounts for 85 percent of the true variance at age 15 years and it is predictable from age 12. Broad visualization or Gv stability was found to be very high, and for boys there were no changes in rank-ordering of the subjects. For crystallized intelligence there were considerable changes with about 65% to 75% of the true variance at the second occasion being accounted for by the measurement at the first occasion. The authors suggest that a possible interpretation of the high degree of stability of Gv is that at this age level there is virtually no systematic training directly or indirectly related to Gv. Gc is subject to several sources of influence both in and out of school and because the amount of efficiency of training is different for the students, the rank-ordering with respect to Gc changes over time. Additionally findings indicated that for both sexes that overachievers in verbal-educational areas at age 12 years continue to be overachievers at age 15 years. Only girls in this group develop particularly well in the more specific area of vocabulary; similarly, only girls among the underachievers develop unfavorably in this particular domain. For girls there was a higher loading of the Swedish language variable on the Gc factor. Rather than implying different mechanisms for change in boys and girls, the results suggested that language mastery gives particular payoffs for the acquisition of word knowledge, over and above the observation that those who already have a large vocabulary continue to have an advantage. The finding that Gc is negatively related to Gv at age 15 years suggests that overachieving girls are turned off from and underachieving girls are turned on to experiences that are beneficial for spatial-visual performance. Finally, the authors

suggest that although Gc skills may depend on fluid intelligence, it may not necessarily follow that between two points in time those high in fluid intelligence are turned on to schooling more and more, and those low in fluid intelligence are increasingly turned off, as such a relation would indicate.

In an exploratory factor analysis of the Kaufman Assessment Battery for Children (K-ABC) and the Kaufman Adolescent and Adult Intelligence Test (KAIT), Kaufman (1993) found that the KAIT two-factor solution offers a clear-cut crystallized-fluid distinction that parallels previous analyses for a clinical population and for six samples of normal individuals ranging in age from 11 to 14 to over 70 years. Joint factor analysis of the KAIT with the WISC-R at ages 11 to 16 and with the WAIS-R at ages 17 to 82 indicated that the crystallized and verbal subtests do load on the same factor, but the fluid and performance subtests are each confined to separate factors. Thus, the crystallized and verbal scales measure the same construct, but the fluid and performance scales measure different constructs. Finally, the results are suggestive that the scales intended to provide estimates of intelligence on the K-ABC include a majority of subtests that are poor measures of g for ages 11 and 12. In contrast, the KAIT intelligence scales included a majority of subtests that were good measures of g in separate KAIT analysis.

Kaufman further states that these results were based on a predominantly normal sample with average intelligence, and this conclusion may not hold for referred children and/or children with below-average intelligence. The K-ABC may be the preferred instrument for children suspected of retardation (who are not likely to be able to handle the formal operational tasks in the KAIT) or children suspected of learning disabilities (who are likely to benefit by having the achievement subtests excluded from the measure

of intelligence). For children referred to developmental clinics and the scope of the current study, this provides support for the use of the K-ABC.

Cultural Considerations in Intelligence Testing for Children

Recent studies that investigate culture and children in relation to fluid and crystallized intelligence are very limited, and this is an area that the current research addresses. The history of the investigation of culturally different children has been plagued by design problems, psychometric limitations, and limitations in scope (Bracken, Howell, & Crain, 1993).

One investigation was undertaken studying the relationships between fluid and crystallized cognitive abilities of African American and Caucasian mothers and their biological children. Bracken et al. (1993) found significant differences between racial groups on both fluid and crystallized abilities. Given the premise that crystallized abilities are most affected by societal exposure, acculturation, educational opportunities, and benefits derived from higher socioeconomic status, the expected, significant differences existed between Caucasians and African-Americans in the children studied. This aligns with historical, empirical evidence of significant differences existing between samples of African-Americans and Caucasians; differences are well documented in comprehensive literature reviews (Shuey, 1966).

Differences have been found to exist between racial groups, specifically in children's fluid intelligence, with Caucasian children scoring higher than their African American counterparts. This finding supports Jensen's (1980) contention that IQ discrepancies are often greatest on tests thought to be culturally loaded. In addition it was found that mother and child correlations for crystallized abilities were significantly

greater than the correlations of mother-child fluid abilities for the total sample. While mother's crystallized intelligence best predicted children's crystallized abilities and mother's fluid intelligence best predicted children's fluid abilities, mother-child crystallized abilities were more strongly related than fluid abilities. These findings suggest that the two forms of intelligence are relatively unique and differentially affected by environmental influences.

More recently, Garcia and Stafford (2000) examined the cross-ethnic predictive validity of Ga and Gc for reading achievement among low SES, English speaking White and Hispanic students. Subtests of the Woodcock-Johnson Psychoeducational Battery – Revised (WJ-R) were used to measure basic reading skills and reading comprehension. The purpose of the study was to determine whether the relations among phonetic coding (Ga), crystallized intelligence (Gc), reading decoding and reading comprehension differ significantly between the White and Hispanic students. Results indicated that there are no differences between ethnic groups in the prediction of reading ability and that phonetic coding and crystallized intelligence together are strong predictors of reading achievement. These findings are enlightening in that both phonetic coding (Ga) and crystallized intelligence (Gc) are moderately to highly loaded in cultural content and linguistic demand. Consequently, previous research has argued that relations among reading achievement and phonetic coding and crystallized intelligence might differ between Whites and Hispanics when linguistic and cultural demands are high (Figueroa, Delgado, & Ruiz, 1984; Ortiz, Flanagan, & McGrew, 1998). Garcia and Stafford argue that the degree of linguistic demand in their study is relatively equal for both Whites and Hispanics because only Hispanic participants whose primary language was English were

included in the sample. Therefore, the nonsignificant interaction effects between ethnicity and phonetic coding (high in linguistic demand) were expected. The authors note the need for Gf-Gc ability testing and treatment relevance research. Recommending that more research is needed in a broader population and cautioning that although this investigation provided evidence for cross-ethnic predictive validity of Ga and Gc for reading achievement in English-speaking Hispanic children, replication of these results in other linguistically and culturally diverse populations is needed. This also can be seen as providing support for the present research on Gf-Gc in Native American children.

Prenatal Alcohol Exposure Effects on Measures of Crystallized and Fluid Intelligence

National surveys indicate that 60 percent of all women in the United States consume some alcohol (National Institute on Alcohol Abuse and Alcoholism [NIAAA], 2000). Surveys among the Navajo and Plains tribes show that only 13 to 55 percent of women drink (Levy & Kunitz, 1974; Longclaws, Barnes, Greive, & Dumoff, 1980; Whitaker, 1982). While the percent of population drinking within each tribe influences the findings, drinking style is more relevant to severity of abuse (May, 1982). For example, the highest percentage of drinking women is found among Plains Tribes 50-55% higher (Whitaker, 1982) with considerably lower percentages among the Pueblo and Navajo 13-23%, respectively (Levy & Kunitz, 1974). Consequently, the Plains Tribes had the highest incidence of fetal alcohol damage (May, 1982). Notably the Plains rate of Fetal Alcohol Syndrome (FAS) is five to seven times higher than the other tribes (May, 1982), and this is much higher than would be dictated solely by the proportion of drinkers. It has been suggested that a normative pattern of social regulation exists, in which Plains tribes allow for more individuation of behavior, especially alcohol abusive

behavior (May, 1982). More Plains Indian women are permitted to follow alcohol abusive behaviors, while the low incidence rates of the Pueblo and Navajo exemplify tighter control exercised on individuation and alcohol abuse (May, 1982). Additionally, among American Indian groups, the period of childbearing is longer than that of the general population (Broudy & May, 1983). The combination of sustained alcohol abuse and the prolongation of child bearing years increase the risk for FAS (May, 1982).

The epidemiology of FAS is more solidly established for American Indians than for any other ethnic population in the world. This in part is due to the publication of the initial diagnostic studies which included a disproportionately large number of native children (Ulleland, 1972; Jones & Smith, 1973; Jones, Smith, Ulleland, & Streisguth, 1973). Subsequently, Indians became linked with FAS from the time the syndrome was first reported, and from the earliest studies an assumption was made that FAS was disproportionately high among American Indians. The rate of FAS in the United States is believed to be between 0.5 and 2.0. per 1,000 births (May & Gossage, 2001) compared with the rate of FAS in American Indian communities which ranged from 1.81 to 3.09 per 1000 (May, Gossage, & Romero, 2000).

Additionally, higher maternal age has been cited as increasing the risk of a drinking mother having a child affected by FAS and alcohol related birth defects and alcohol related neurological birth defects. That is, as a mother who uses alcohol ages, each year brings an increased risk of having a child with FAS or more severe alcohol-related effects in general (May, Gossage, & McCloskey, 2002). For example among southwestern Indians (Pueblo, Navajo, and Southwestern Plains) on seven reservations, 82 percent of all mothers of FAS children were 25 or older at the birth of their FAS or

FAS children (May et al., 1983). The average age of mothers with FAS/FAE children was 29.7, while for mothers of children seen in clinics but not diagnosed with FAS or FAE the average age was 26.9. Similarly, in a study of four plateau culture tribes the mean age of Native American mothers of FAS/FAE children was 32 years, while the mean age of mothers of children with no diagnosis was 22 years (Quaid, Kirkpatrick, Nakamura, & Aase, 1993). Burd and colleagues (1996) found in a study of both non-Indian and Indian women, that mothers of FAS/FAE children had a mean age of 27.3 when the affected child was born compared to mothers in the control group who had a mean age of 24.8 years when they gave birth. Additionally, the association between maternal age and FAS/FAE is found in the general U.S. population survey which revealed that women who continued to drink during the third trimester of pregnancy were older than those who quit drinking earlier in pregnancy (Day, Cottreau, & Richardson, 1993).

Extensive literature on cognitive dysfunction among children with FAS exists. Numerous researchers have consistently found intellectual deficits in children with FAS (Mattson, Riley, Gramling, Delis, & Jones, 1997; Streisguth, Barr, & Sampson, 1990). On tests of academic achievement, children with FAS/FAE tend to earn lower scores on arithmetic tests than on other tests (Streisguth, Barr, Carmichael, Sampson, & Bookstein, 1994). Additionally, researchers have also found marked deficits in children prenatally exposed to alcohol and have reported that the average performance of children with FAS is approximately 2 standard deviations below the normal mean IQ of 100 (Mattson et al., 1997). These researchers found that children who were prenatally exposed to substantial

amounts of alcohol evidenced high levels of intellectual deficits, irrespective of the degree of any physical dysmorphia.

As might be deduced from the previous discussion, children's poor reading skills are related to relatively poor verbal fluid intelligence which leads to problems in learning to read and result in reduced exposure to print (Landon et al., 1998). Similar findings were reported by researchers investigating verbal and non-verbal fluency in children with heavy prenatal alcohol exposure (Schonfeld, Mattson, Lang, Delis, & Riley, 2001). Other studies have documented verbal fluency impairments in alcohol-exposed children (Kodituwakku, Handmaker, Cutler, Weathersby, & Handmaker, 1995). This work was further explained by the research of Kodituwakku, Kalberg, Robinson, & May (2003), whose investigation of American Indian children with confirmed substantial alcohol exposure, using measures of crystallized and fluid intelligence, reported that scores on tests of fluid intelligence were more than one standard deviation below that of the control group, and there was no significant group difference on the test of crystallized intelligence. This study demonstrates that tests of fluid intelligence discriminate between alcohol-exposed and control groups, independently of low scores on the test of crystallized intelligence. Moreover, nonverbal tests of fluid intelligence may prove to be useful tools in cross cultural studies and seem to be less culturally biased than verbal tests (Kodituwakku et al, 2003). Finally, the present study uses an epidemiology data set to further the controlled study of Kodituwakku et al (2003) and provide increased knowledge on the differences of crystallized intelligence and fluid intelligence in American Indians. In particular, the present study utilizes an analysis of several measures of crystallized and fluid intelligence, whereas the Kodituwakku, study was

limited to the Raven's and the PPVT-R. Additionally, the Kodituwakku study does not include maternal age or educational level, which the present study includes.

Summary

In summary, then, previous empirical research suggests that crystallized and fluid intelligence: a) can be operationalized and measured; b) may vary to some degree among cultures or socio-economic groups; and c) differ in groups with certain psychological problems, such as children who have histories of prenatal alcohol exposure. However, to date studies are limited in investigating both the differences in crystallized and fluid intelligence in American Indian children and also in American Indian children who have been exposed to alcohol prenatally.

Chapter 2

Methodology

The Present Study

The purpose of this study is to investigate research questions concerning differences between crystallized intelligence and fluid intelligence within Plains Indian children referred for Developmental Clinics. Previous research indicates that patterns of fluid and crystallized intelligence can be systematically measured, and that maternal fluid and crystallized intelligence effect a child's fluid and crystallized abilities. In addition, maternal alcohol use will be investigated to determine the effect of prenatal alcohol exposure on children's fluid and crystallized intelligence.

This study has both theoretical and practical significance. By comparing alternative models of the structure of intelligence, a better understanding of the nature of intelligence will be achieved. Additionally, this study may contribute to the literature, in an area that has not been previously researched, on crystallized and fluid abilities in Plains Indian children and their relationship to maternal factors such as education and prenatal alcohol use.

Hypotheses

Study One

1. On average, among Plains Indian children referred from the Confederated Salish & Kootenai Tribe, the Cheyenne River Sioux Tribe, the Turtle Mountain Band of Chippewa Indians, the Sisseton-Wahpeton Sioux Tribe, and the Blackfeet Tribe, the native children will obtain significantly higher mean scores on measures of fluid intelligence as compared to their mean

scores on crystallized intelligence as measured by the Wechsler Abbreviated Scale of Intelligence (WASI), the Peabody Picture Vocabulary Test (PPVT-R), the Kaufman Brief Intelligence Test (K-BIT), and the Raven's Progressive Matrices (Raven).

2. Mother's education will correlate positively with the child's performance on crystallized test performance.

Study Two

3. Maternal age (at birth of the child) of FAS diagnosed children will significantly affect the children's performance on measures of fluid and crystallized intelligence, in that older maternal age will negatively effect the child's performance on both fluid and crystallized intelligence.
4. Prenatal alcohol exposure (i.e., children with FAS) will negatively affect children's performance on measures of fluid and crystallized intelligence.

Method

This research is based on original analyses of data from two National Institute on Alcohol Abuse and Alcoholism funded prevalence studies (ROI AA09440 and UOI AA11685) of the epidemiology of Fetal Alcohol Syndrome (FAS), studies that are well established among the five tribes listed. The overall research involves a multi-site/system of comprehensive FAS prevention for American Indians. All children in the study ($n = 578$) were referred to developmental clinics held on the five Plains Indian reservations.

The research project from which the data are drawn is measuring the effectiveness of a comprehensive, public health model, reservation/community wide FAS prevention program. It utilizes a randomized control design to assess tertiary, secondary, and

primary prevention techniques applied by Plains Indian personnel. Utilizing techniques of research and prevention applied in various American Indian Communities over previous years, and through more rigorous operationalization, the overall NIAAA funded study will determine whether community-wide prevention of FAS is effective, to what extent, and which aspects of prevention are most viable. Furthermore, this study is intended to significantly advance the knowledge base of the epidemiology of FAS, adult drinking characteristics, and maternal alcohol risk factors among American Indians (May, 1994, 1998, 2003).

Specific aims of the Fetal Alcohol Syndrome Epidemiology Research (FASER) are: to implement the Institute of Medicine (IOM) comprehensive FAS prevention program; to measure the effectiveness of comprehensive FAS prevention through formative evaluation of specific prevention components and change in age-specific FAS prevalence rates and specific secondary (proxy) measures in Plains Indian communities (4 prevention and 2 control); to measure change in adult drinking and associated risk factors over time; to determine the overall effect of comprehensive FAS prevention over control sites, and to further delineate and define maternal risk factors for FAS.

Cognitive/behavior evaluations are performed for all children who are referred and are older than 2.5 years of age. A number of test instruments used in the FASER project, were selected for their potential to reflect the core deficits of FAS diagnosed children. The instruments fall into the following four broad categories: intellectual, behavioral, academic, and neuropsychological measures. As a result of the extensive testing in this research cohort, the clinical data encompass a rich cross-section of instructive psychological, educational, behavioral, and neuropsychological information.

All children referred are clinically assessed by a pediatric dysmorphologist, psychosocial testing is performed, a maternal interview is administered, and all clinical work is supplemented by a chart review and a medical history summary.

The three major categories of symptoms which are present in FAS children and serve as the scope of the clinical data in the FASER project are poor growth indicators, deficient intellectual and social capabilities, and a consistent pattern of minor structural anomalies (Aase, 1994). FASER follows the guidelines of the Institute of Medicine (IOM;1996) committee recommendations. For the diagnosis of FAS there must be:

- 1) Evidence of a characteristic pattern of facial anomalies that includes features such as short palpebral fissures and anomalies in the premaxillar zone (for example flat upper lip, flattened philtrum, and flat mid-face).
- 2) Evidence of growth retardation as in at least one of the following: low birth weight for gestational age, decelerating weight over time not due to nutrition, and disproportional low weight to height.
- 3) Evidence of central nervous system neurodevelopmental abnormalities, as in at least one of the following: decreased cranial size at birth, structural brain anomalies (e.g., microcephaly) and neurological hard or soft signs such as impaired fine motor skills, neuro-sensory hearing loss, poor tandem gait, or poor eye-hand coordination (IOM, 1996, pp. 76-77).

The FASER project has further operationalized and standardized the above criteria for the determination of FAS (Hoyme et al., 2005). Two dysmorphologists for this research project were trained by one of the physicians who initially described FAS (Kenneth L. Jones) and have participated in diagnostic training and validation studies in South Africa in 1997, 1999, and 2002 under the auspices of an NIAAA initiative and supplemental grant award to the research team. Additionally, all children seen receive a treatment plan and referral to appropriate services for outstanding medical or developmental needs. Other descriptive data provide baseline information on maternal risk factors of mothers of all referred children and of identified heavy drinking mothers will also be collected.

All children are identified as members of their respective tribes. Subjects are both male and female, and range in age from 3 months to 17 years (see Table 2). All children were given intellectual measures that adequately test the respective age ranges. For children over the age of four there were the: a) Kaufman Brief Intelligence Test (K-BIT; Kaufman, 1990) for verbal and nonverbal intelligence, and the b) Wechsler Abbreviated Scale of Intelligence (WASI; Wechsler, 1999). For children 6 and over there was: c) Raven's Progressive Matrices (Raven, 1983), a measure of nonverbal reasoning ability as a supplemental culturally neutral intelligence test. The d) Peabody Picture Vocabulary Test-Revised (PPVT-R; Dunn & Dunn, 1981) was used for children 2.5 years and older.

Additionally, mothers were required to complete a structured interview of 300 items. For the purposes of this study, the mother's reported educational level, age, and prenatal alcohol use were used from the interview. An Institutional Review Board (IRB)

Protocol was submitted to and approved by, the University of New Mexico (Main Campus and Health Science Committees) and the Indian Health Service IRB to fulfill human subject protection, guidelines and requirements, especially due to the vulnerability of the population.

Study One

Table 2.

Descriptive Statistics of age of the sampled American Indian children.

	N	Mean	Std. Dev.	Min.	Max.
Age	578	89.82	53.13	3 mos	17 yrs

Table 3.

Frequency and percentage of Gender and FAS.

Variables	Frequency	Percent
Sex		
Male	326	56.1
Female	255	43.9
FAS		
FAS	75	12.8
Not FAS	472	80.8
Deferred	37	6.3

In Table 3, other variables which describe the composition of the sample are presented.

Fifty-six percent of the children in the study were male and 44% were female. Overall,

12.8% of the children in the clinic were diagnosed with FAS and another 6% were deferred, awaiting further testing before a definitive FAS/not FAS diagnosis can be made. The total number of subjects for this investigation is 584. But the actual number who were administered the various test differs from test to test.

Measures

Measures of Crystallized Intelligence

K-BIT Vocabulary Subtest. Vocabulary is an 82-item measure of verbal ability that requires oral responses for all items. Part A, Expressive Vocabulary (45 items) is administered to individuals of all ages and asks the participant to provide the name of a pictured object such as a lamp or a calendar. Performance on the vocabulary subtest is a measure of crystallized intelligence, the kind of learning and problem solving that depends heavily on formal schooling and cultural experiences (Kaufman, 1993, p. 5). Reported reliability coefficients range from .89 to .98 (Kaufman, 1983).

PPVT-R. The Peabody Picture and Vocabulary Test-Revised is a measure of receptive vocabulary and is appropriate for individuals between the ages of 2 years and adult. Form L., which was used in the study, evidences low to adequate internal consistency for screening and research purposes (range = .70 to .79 for 4 to 6 year olds) (Dunn & Dunn, 1981). As a measure of receptive vocabulary, the PPVT-R has been reported to be an appropriate measure of crystallized abilities (Bracken et al, 1993).

WASI Vocabulary Subtest and Similarities Subtest. The WASI Vocabulary test requires the participant to name pictures, which are displayed one at a time (items 1-4). Items 5-42 consist of orally and visually presented words that the participant orally defines. Vocabulary is a measure of the individual's expressive vocabulary, verbal

knowledge, and fund of information. Additionally it is a good measure of crystallized intelligence (Wechsler, 1999, p. 4). The Similarities subtest includes 4 picture items and 22 verbal items. For each of the picture items, the participant is shown a picture of three common objects on the top row and four response options on the bottom row. The participant responds by pointing to the one response option that is similar to the three target objects. For each verbal item a pair of words is presented orally, and the participant explains the similarity between the common objects or concepts that the two words represent. The similarities subtest is a measure of verbal concept formation, abstract verbal reasoning, and general intellectual ability. These two subtests are measures of crystallized intelligence (Horn, 1985; Kaufman, 1994; Woodcock, 1990).

Measures of Fluid Intelligence

K-BIT Matrices subtest. The Matrices subtest is a 48-item non-verbal measure composed of several types of items involving visual stimuli, both meaningful (people and objects) and abstract (designs and symbols). All items require understanding relationships among the stimuli, and all are multiple choice, requiring the participant to either point to or otherwise indicate the correct response. A majority of the matrices items involve abstract stimuli and require the participant either to solve a 2x2 or 3x3 matrix to complete a pattern of dots. Each abstract item demands nonverbal reasoning and flexibility in applying problem-solving strategies. Many items also assess the ability to negotiate several variables simultaneously. The Matrices, and the overall ability to solve visual analogies, especially those with abstract stimuli, have proven to be excellent measures of fluid abilities. This task is consistently associated with the factor assessing fluid

intelligence (Kaufman, 1990, p.5). Reported reliability coefficients range from .74 to .95 (Kaufman & Kaufman, 1990).

Raven's Progressive Matrices (Raven). The Raven is widely considered to be among the best measures of fluid abilities available (Jensen, 1980; Sattler, 1992). In addition, Horn (1991) cites visual matrices as a common measure of fluid abilities. In particular, the Raven is used widely in cross-cultural studies because of its low culturally loaded item content. The test is a nonverbal test of reasoning ability based on figural test stimuli. It can be administered individually or to a group. The test measures the ability to form comparisons, to reason by analogy, and to organize perceptions into systematically related wholes (Sattler, 1992). The Standard Progressive Matrices is used primarily for persons from 6 to 17 years of age, although it also can be administered to adults. It contains 60 items presented in five sets, with 12 items per set.

The child is presented with a matrix-like arrangement of figural symbols and must complete the matrix by selecting the appropriate missing symbol from a group of symbols. One piece or design is left out of the matrix, and the child must select, from a group of six to eight choices, the one that best completes the matrix. The form takes between 15 and 30 minutes to administer. The Raven is appropriate for both adults and young children and is sufficiently reliable for both individual assessment and research purposes. The Raven provides percentile ranks that can be converted to standard scores only for broad ranges of ability. Reported reliability coefficients range from .71 to .93 (Sattler, 1992).

Wechsler Abbreviated Scale of Intelligence Block Design Subtest and Matrix Reasoning Subtests. The WASI Block Design subtest consists of a set of 13 modeled or

printed two-dimensional geometric patterns that the participant replicates within a specified time limit using various two-color cubes. The subtest taps the abilities related to spatial visualization, visual-motor coordination, and abstract conceptualization. The Matrix Reasoning subtest is a series of 35 incomplete gridded patterns that the participant completes by pointing to or stating the number of the correct responses from five possible choices. The Block Design and Matrix reasoning are measures of fluid ability (Horn, 1985; Kaufman, 1994; Woodcock, 1990).

Statistical Package for the Social Sciences (SPSS) for windows was the statistical package used in the analyses of data for frequency, regression and ANOVA analyses. Results are presented according to the hypothesis that they test. Significant findings at or below the .05 and .01 level are reported. Data in the present study was extracted from a larger epidemiology study by selecting those children who were members of the Plains tribes, and who had completed tests of crystallized and fluid intelligence.

Chapter 3

Results

In order to establish the difference in fluid (Gf) and crystallized intelligence (Gc), child performance scores on intelligence subtests reported to be good measures of Gf and Gc were analyzed using ANOVA's. To examine the correlation between mother's education and the child's crystallized intelligence, ANOVA's were first used to provide a descriptive understanding of the data, and then simple linear regressions were ultimately used to assess the relationship. In study two, this same statistical procedure was used to investigate the relationship of maternal age and children's performance on measures of Gf and Gc. To test the effect that FAS has on children's performance on measures of Gf and Gc, a one-way ANOVA was used with each of the six intelligence measures to detect significant differences. Additionally, in an effort of finding if the child's gender is a possible effect in these analyses, gender was used as the grouping and a series of independent sample *t*-tests on each of the intelligence scores revealed that there were no gender differences or gender effects, (*p* values > .2).

Hypothesis 1.

On average, among Plains Indian children referred from the Confederated Salish & Kootenai Tribe, the Cheyenne River Sioux Tribe, the Turtle Mountain Band of Chippewa Indians, the Sisseton-Wahpeton Sioux Tribe, and the Blackfeet Tribe, the native children will obtain significantly higher mean scores on measures of fluid intelligence as compared to their mean scores on crystallized intelligence as measured by the Wechsler Abbreviated Scale of Intelligence (WASI), the Peabody Picture Vocabulary

Test (PPVT-R), the Kaufman Brief Intelligence Test (K-BIT), and the Raven's Progressive Matrices (Raven).

Use of the paired *t*-test assumes that the differences of the two related samples are normally distributed. Therefore, this assumption was checked before the actual paired *t*-test was done. The results show that the sample of the differences is normally distributed (see Table 4 and Figure 2 for normality test results); thus the paired *t*-test was utilized.

Using the WASI to test the hypothesis.

Table 4.

Tests of Normality for the WASI Verbal (Gc) and WASI Performance (Gf) Subtests

	Kolmogorov-Smirnov(a)			Shapiro-Wilks		
	Statistic	df	Sig.	Statistic	df	Sig.
VIQ-PIQ	.089	68	.200(*)	.988	68	.760

* This is a lower bound of the true significance.

a Lilliefors Significance Correction

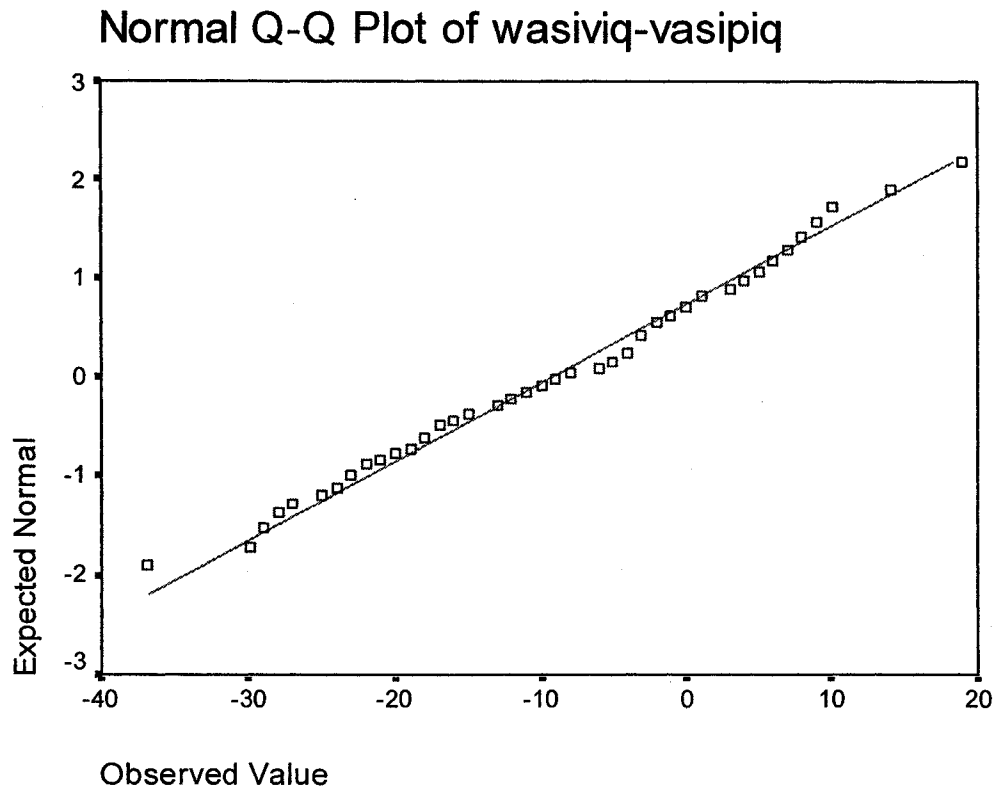


Figure 2. Normality plot of WASI VIQ – WASI PIQ.

The first series of analyses investigated the differences between mean scores on measures of crystallized and fluid intelligence. A paired sample *t*-test was conducted on the WASI Verbal Scale subtest scores and WASI Performance scale subtest scores. The comparisons indicated significant differences. Overall, as predicted, the native children performed better on the WASI Performance Scale subtest measuring fluid intelligence (Gf) as compared to the WASI Verbal scale subtest scores which measures crystallized intelligence (Gc).

A paired *t*-test ($n = 68$) showed that in general, the American Indian children's fluid intelligence performance is much higher than their crystallized intelligence performance. The former score is 9.3 points higher than the latter on average, and the

t-test is highly statistically significant (see Table 5) as the probability of such a result is <.0001.

Table 5.

Paired sample t-test results for the WASI scores (n= 68).

	Mean	Std. Dev.	Min.	Max	95% CI of difference	Effect Size (d)	Sig.
VIQ(Gc)	81.68	11.25	55.00	109.00			
PIQ(Gf)	90.99	13.16	62.00	119.00			
VIQ – PIQ	– 9.31	12.62			(-12.36, -6.25)	– 0.76	0.000

Using the Kaufman Brief Intelligence Test (K-BIT) to test the hypothesis. The normality assumption check showed that it may not be plausible to assume that the sample difference is normally distributed (see Table 6 and Figure 3) on the K-BIT.

Table 6.

Normality test for K-BITvs – K-BITms.

	Kolmogorov-Smirnov(a)			Shapiro-Wilks		
	Statistic	df	Sig.	Statistic	df	Sig.
kvs-kms	.071	284	.001	.985	284	.004

a Lilliefors Significance Correction

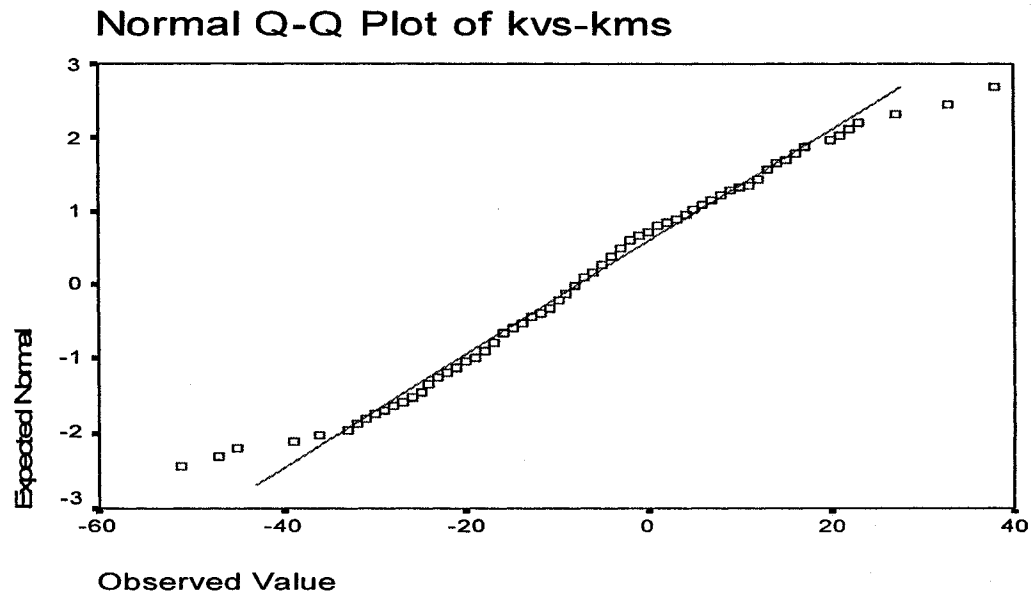


Figure 3. Normal Plot for K-BITvs – K-BITms.

Because of the possible variation in a normal distribution, in addition to the t -test, a nonparametric method might be more appropriate than the just mentioned paired t -test. However, when the sample difference is plotted it is quite symmetric as seen in Figure 4.

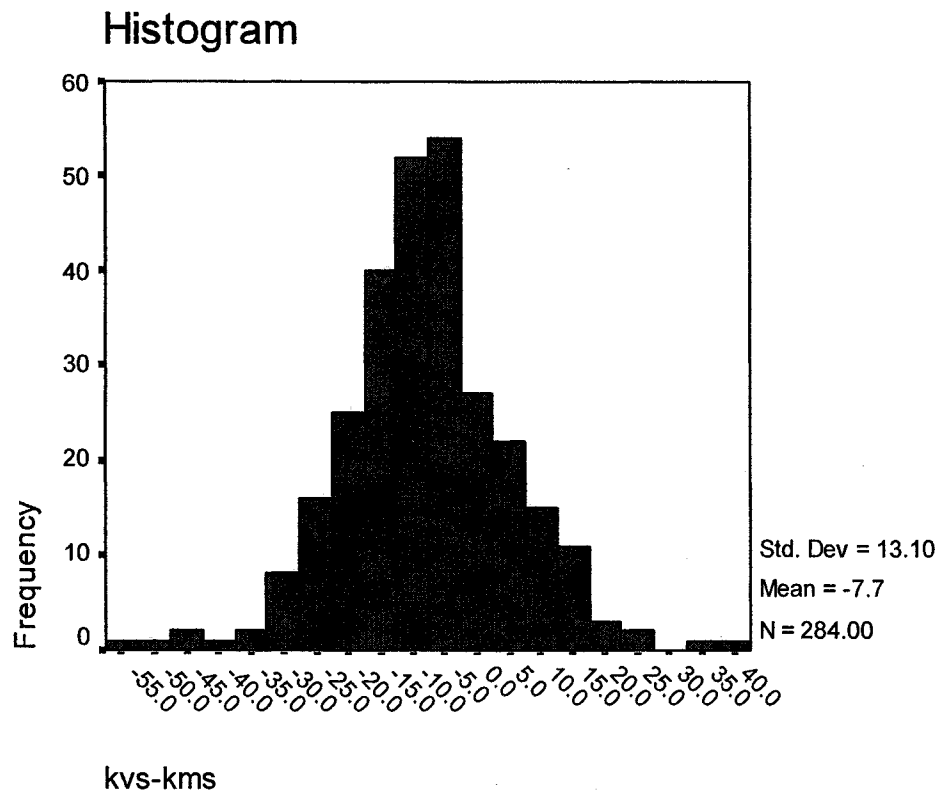


Figure 4. Histogram of K-BITvs – K-BITms).

First a paired t -test was performed for the 284 children who were administered the K-BIT. The results indicate, once again, that the native children performed significantly better on K-BIT matrices scale (Gf) as compared to the K-BIT verbal scale (Gc) (see Table 7). Therefore, the American Indian children again were found to perform better on the measures of fluid intelligence.

Table 7.

Paired samples test Results for K-BIT Scores (n = 284).

	Mean	Std. Dev.	Min.	Max	95% CI of difference	Effect Size (d)	Sig.
KVS	86.73	12.83	39.00	137.00			
KMS	94.51	13.67	40.00	132.00			
KVS-KMS	- 7.70	13.10			(-9.23, -6.17)	- 0.59	0.000

A non-parametric Wilcoxon signed rank test revealed a highly significant p -value of .000. Hence, both the nonparametric method and paired t -test indicate that the American Indian children's matrices scores (Gf) are higher than their verbal scores (Gc), in general. See Tables 8 and 9 for Wilcoxon signed ranks test results.

Table 8.

Wilcoxon Signed Ranks Test

Ranks of Kaufman Matrices Scale – Kaufman Verbal Scale.

		N	Mean Rank	Sum of Ranks
KMS –	Negative	64(a)	114.13	7304.50
KVS	Ranks			
	Positive	214(b)	147.09	31476.50
	Ranks			
	Ties	6(c)		
	Total	284		

a KMS < KVS

b KMS > KVS

c KMS = KV

Table 9.

Wilcoxon Signed Ranks Test.

	KMS - KVS
Z	-9.011(a)
Asymp. Sig. (2-tailed)	.000

a Based on negative ranks.

b Wilcoxon Signed Ranks Test

Therefore, using two different tests, Hypothesis 1 was supported. American Indian children in this sample performed better on sub-tests of fluid intelligence measures than on subtests of crystallized intelligence measures for both the WASI and the K-BIT.

Hypothesis 2.

The second hypothesis of this study was that the mother's education will correlate positively with the child's performance on crystallized test performance as measured by mother's report of educational level and the children's performance on crystallized measures of intelligence: the WASI verbal scales subtest score (VIQ), K-BIT Verbal Scale subtest score (KVS) and the PPVT-R. Because the sample contained only 10 mothers who reported educational level who had children who had WASI Verbal scale scores (VIQ) the first planned analysis mentioned above was omitted.

To test this hypothesis, analysis of variance was first used to provide a descriptive understanding of the data, and then simple linear regression was ultimately used to assess the relationships between each of the three crystallized intelligence measures (VIQ, KVS and PPVT-R) and mother's highest education level. Mother's educational level was categorized into three groups: less than high school, high school, and higher than high

school (see Table 10). Then a one-way ANOVA was performed on each of the six intelligence variables with education group as the factor variable.

Table 10.

Descriptive statistics for mother's highest level of education completed.

Educational level	<i>n</i>	Percent
<HS	122	44.7
HS	106	38.8
>HS	45	16.5
Total	273	100.0

Note: The majority of the mothers (82%) have some high school or high school diploma. Of the entire sample, only 273 mothers completed the interview questionnaire which resulted in the $n=273$.

The one-way ANOVA was performed on each of the two crystallized intelligence variables with sufficient sample sizes. Neither of the tests shows that when using mother's education as a categorical variable, it is a significant factor in predicting the child's crystallized intelligence scores (see Table 11).

Table 11.

One-Way ANOVA of crystallized intelligence and mother's education groups.

Intelligence Measure	Mother's Education	<i>n</i>	Mean	Standard Deviation	<i>F</i>	Sig.
<i>PPVT-R</i>	< HS	30	77.77	15.21	2.314	.107
	HS	23	88.13	20.89		
	> HS	13	83.92	16.11		
<i>KVS</i>	< HS	84	84.58	11.36	1.289	.278
	HS	82	87.48	13.88		
	> HS	24	87.54	10.27		

The regression analysis on Kaufman Verbal scales subtest scores showed that mother's educational level is positively associated with the child's crystallized intelligence performance. The association is significant at the .05 level. Diagnosis plots, normality plot (see Figure 5) and residual plot (see Figure 6) indicate that the linear model is reasonable here.

However, though the relationship was found to be significant, mother's education level alone can hardly help predicting the children's VIQ scores, since the R-square of this model is very small—only 0.023, which means only a bit more than 2% of the variation in VIQ scores can be explained by the independent variable, mother's education level (see Table 12).

Table 12.

Linear regression model: KVS (Dependant variable), n = 190.

	β	Std. Error	t	p -value	R^2
Intercept	78.88	3.61	21.85	.000	.023
Mother's Education	2.07	.99	2.09	.038	

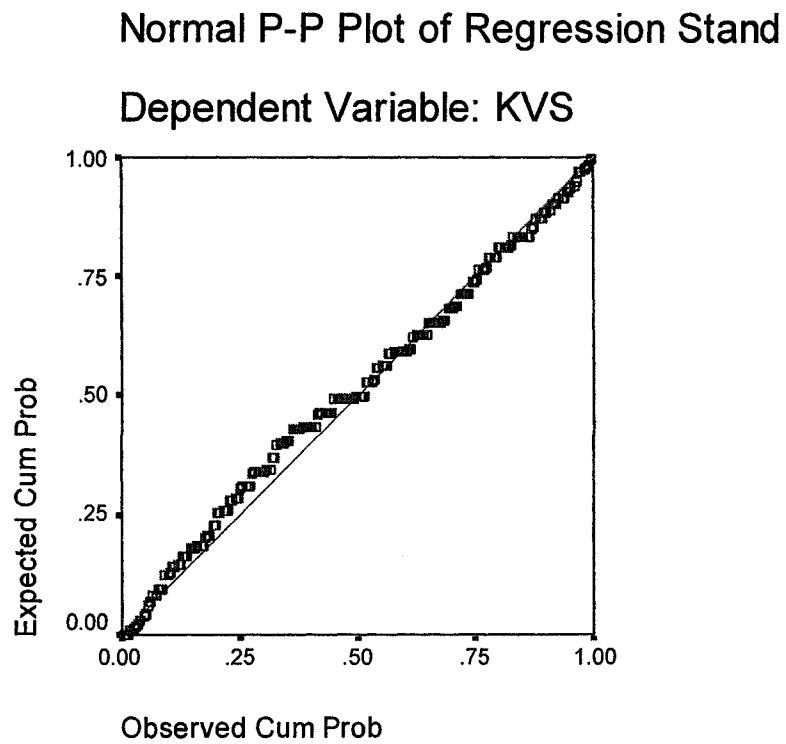


Figure 5. Normal plot.

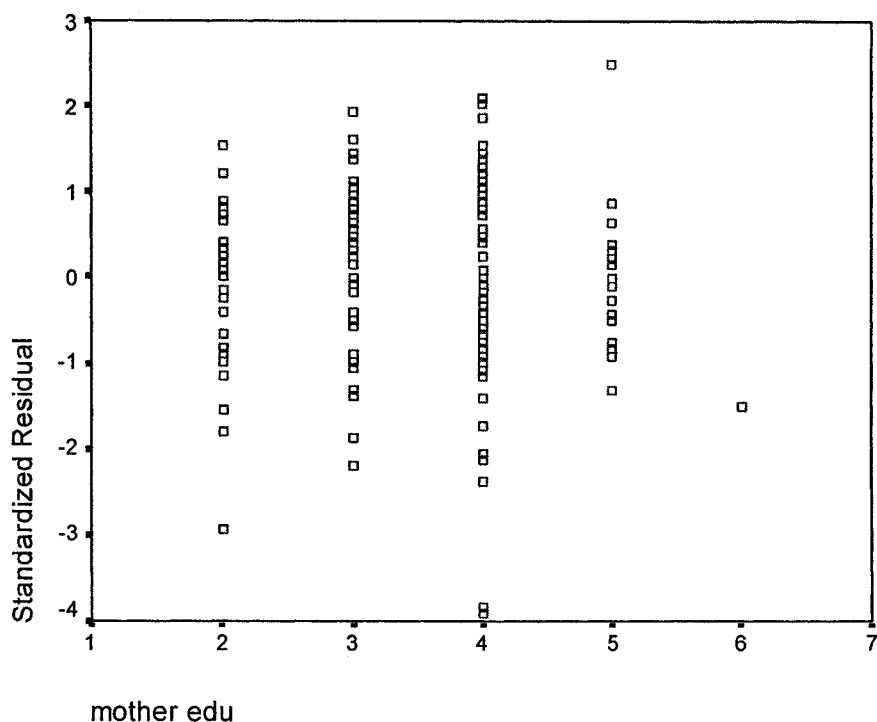


Figure 6. Residual plot.

The analysis on PPVT-R did not find the relationship between the crystallized intelligence measure and mother's highest education level to be significant (see Table 13). Thus, Hypothesis 2 was only partially supported in one of the test comparisons and this hypothesis was rejected.

Table 13.

Linear regression model: PPVT-R (dependent variable), n = 65.

	β	Std. Error	t	p -value	R^2
Intercept	71.97	8.76	8.22	.000	.024
Mother's Education	2.91	2.32	1.25	.215	

Study Two

Hypothesis 3.

The third hypothesis of this study was that maternal age (at birth of the child) will be significantly related to the children's performance on measures of fluid and crystallized intelligence, in that older maternal age will be negatively correlated with the child's performance on both fluid and crystallized intelligence.

To test this hypothesis, first a one-way ANOVA was performed on each of the six intelligence variables with the age group as the factor variable. Then a simple linear regression was used. Each of the six intelligence measures (both crystallized and fluid) were used as the dependent variable and mother's age was used as the independent variable. For the ANOVA, mother's age at the birth of the child was categorically coded into four groups: younger than 20, 20-24, 25-29, and older than 29 (see Table 14).

Table 14.

Mother's age groups.

	Frequency	Percent
15-19	51	18.5
20-24	107	38.9
25-29	74	26.9
30-40	43	15.6
Total	275	100.0

Table 15.

Descriptives of mother's age.

	<i>n</i>	Minimum	Maximum	Mean	Std. Deviation
<i>Mother's age</i>	275	15	40	24.33	5.170

One-way ANOVA analyses were performed with the four intelligence measures with sufficient sample sizes, using the mother's age as a categorical variable. None of the tests are significant, indicating these intelligence scores do not differ across the mother's age groups (see Table 16).

Table 16.

One-Way ANOVA Results of Intelligence against Mother's age categories.

Intelligence Measure	Mother's Age	<i>n</i>	Mean	Standard Deviation	<i>F</i>	Sig.
PPVT-R	15-19	11	83.00	16.17	2.156	.102
	20-24	29	86.17	17.13		
	25-29	18	77.94	17.05		
	30-40	12	72.00	19.58		
Raven	15-19	8	90.50	11.58	.700	.558
	20-24	15	97.87	11.64		
	25-29	12	93.75	13.16		
	30-40	8	96.25	12.76		
Kvs	15-19	37	88.00	9.49	.893	.446
	20-24	76	84.53	13.86		
	25-29	42	86.67	14.13		
	30-40	30	83.77	12.49		
Kms	15-19	37	96.84	10.22	.770	.512
	20-24	76	93.76	14.19		
	25-29	42	92.24	15.84		
	30-40	30	92.93	15.82		

A summary of the regression analyses follows:

The sample sizes for both the regression analyses with the two WASI measures are too small ($n = 11$) to yield reliable analysis results. Hence these analyses were omitted from the study.

The regression analysis with the Kaufman scales showed no significant relationship between Kaufman Verbal subtest scores (KVS) and the mother's age (see Table 17).

Table 17.

Linear regression model with KVS ($n = 185$).

	β	Std. Error	t	p -value	R^2
Intercept	87.42	4.37	20.00	.000	.032
Mother's Age	-.08	.18	-.43	.668	

The regression with Kaufman Matrices scale subtest scores showed no significant relationship between KMS and the mother's age, either (see Table 18).

Table 18.

Linear regression model with KMS ($n = 185$).

	β	Std. Error	t	p -value	R^2
Intercept	94.60	4.78	19.78	.000	.000
Mother's Age	-.03	.19	-.15	.880	

Following are the descriptive statistics of the PPVT-R measure.

Table 19.

Descriptive statistics of PPVT-R.

	<i>N</i>	Min	Max	Mean	Std. Deviation
PPVT-R	133	40.00	119.00	80.82	14.76

The regression analysis with PPVT-R is significant at an alpha of .05, indicating that the mother's age is negatively related with the child's PPVT-R score. However, a closer look at the data reveals that such a significant result occurred mainly due to outlying observations (see Table 20 and Figure 7).

Table 20.

*Linear regression model with PPVT-R (*n* = 70).*

	β	Std. Error	<i>T</i>	<i>p</i> -value	<i>R</i> ²
Intercept	102.00	10.09	10.11	.000	.062
Mothers Age	-.86	.41	-2.12	.038	

A scatter plot of PPVT-R against mother's age (see Figure 7) shows that two outlying observations are potentially very influential on the regression model: One is a child with an extremely high PPVT-R score (141) and the mother is relatively young (21 years old); the other is a child with an extremely low PPVT-R score (56) and the mother is relatively old (39 years old). A sensible step is to hold out these two observations and redo the regression analysis.

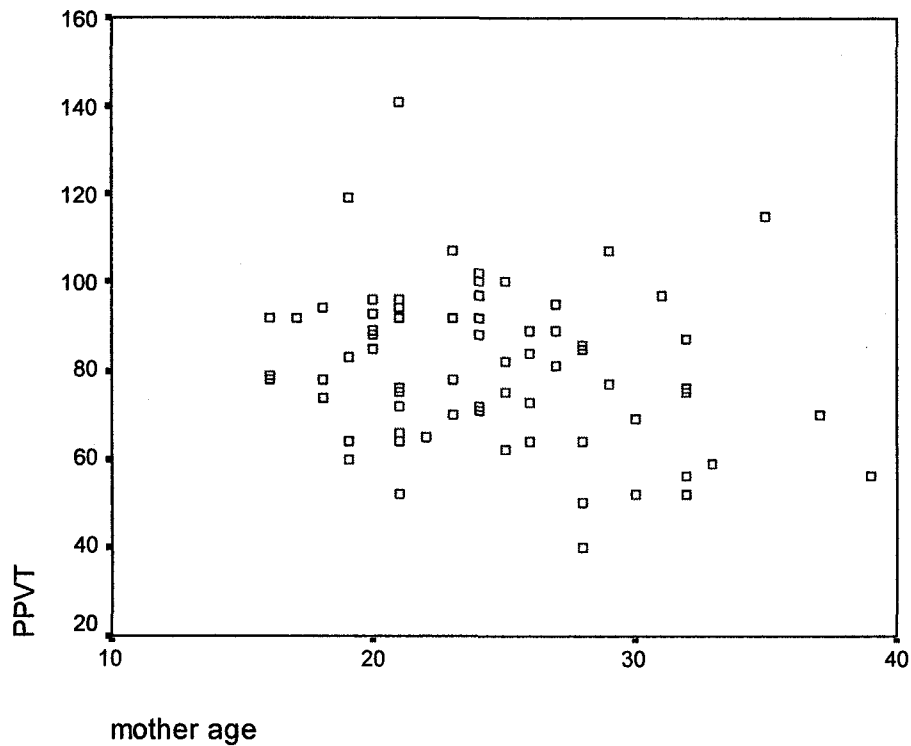


Figure 7. Scatterplot of PPVT-R against Mother's Age.

After holding out the two outliers, the analysis shows that the relationship between PPVT-R and the mother's age is no longer significant ($p = .121$). This confirmed the above conjecture. Therefore we may hesitate to conclude that there is a relationship between the two variables (see Table 21).

Table 21.

Linear regression model with PPVT-R after two outliers held out ($n = 68$).

	β	Std. Error	t	p -value	R^2
Intercept	95.83	9.87	9.71	.000	.036
Mother's Age	-.63	.40	-1.57	.121	

Following are the descriptive statistics for Raven's Progressive Matrices:

Table 22.

Descriptive statistics for Raven's Progressive Matrices.

	<i>N</i>	Min	Max	Mean	Std. Deviation
Raven	83	65.00	112.00	93.58	11.24

The regression analysis with the Raven showed no evidence of relationship between mother's age and the child's Raven score ($p = .941$) (see Table 24).

Table 23.

Linear regression model with Raven's Progressive Matrices ($n = 43$).

	β	Std. Error	<i>t</i>	<i>p</i> -value	R^2
Intercept	94.46	8.19	11.54	.000	.000
Mother's Age	.02	.32	.07	.941	

Additionally, regression analysis of mother's age and FAS diagnosis did not produce a relationship between maternal age, FAS, and intelligence scores (see Tables 24-27; Figures 8-11). Following are the regression models with mother's age as an independent variable.

Table 24.

Linear regression model with PPVT-R for children with an FAS diagnosis ($n = 16$).

	β	Std. Error	<i>t</i>	<i>p</i> -value	R^2
Intercept	85.33	23.36	3.65	.003	.018
Mother's Age	-.41	.82	-.51	.621	

Table 25.

Linear regression model with the Raven for children with an FAS diagnosis (n = 12).

	β	Std. Error	<i>t</i>	<i>p</i> -value	R^2
Intercept	100.90	14.54	6.94	.000	.012
Mother's Age	-.18	.52	-.35	.737	

Table 26.

Linear regression model with KVS for children with an FAS diagnosis (n = 19).

	β	Std. Error	<i>t</i>	<i>p</i> -value	R^2
Intercept	64.13	18.53	3.46	.003	.035
Mother's Age	-.52	.65	.79	.441	

Table 27.

Linear regression model with KMS for children with an FAS diagnosis (n = 19).

	β	Std. Error	<i>t</i>	<i>p</i> -value	R^2
Intercept	85.12	18.36	4.64	.000	.004
Mother's Age	.17	.65	.27	.794	

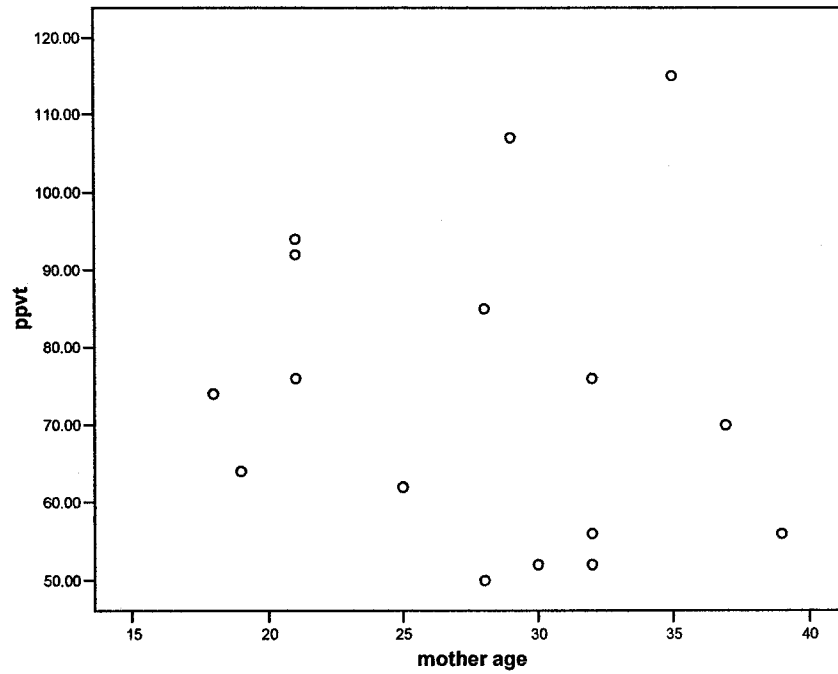


Figure 8. Scatter plot of PPVT vs. mother's age.

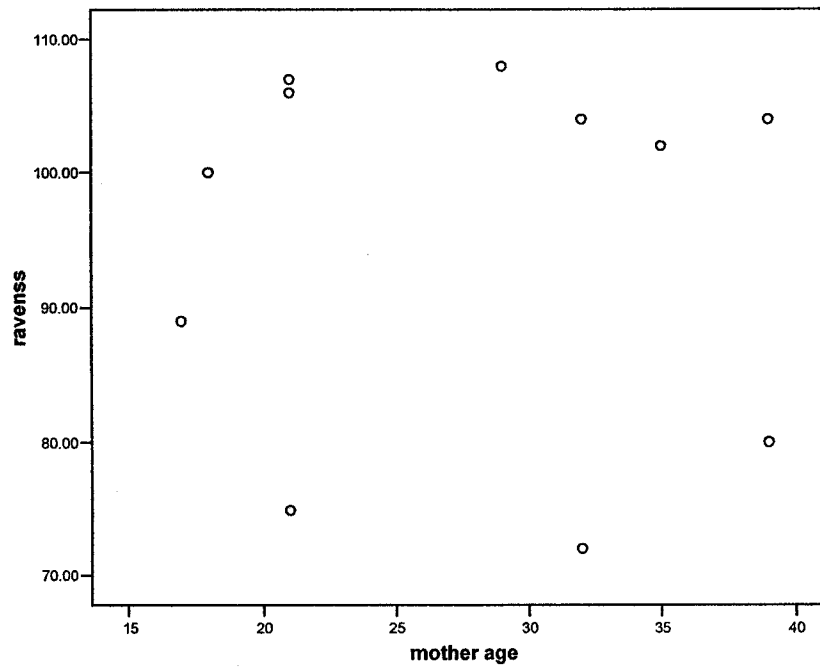


Figure 9. Scatter plot of the Raven vs. mother's age.

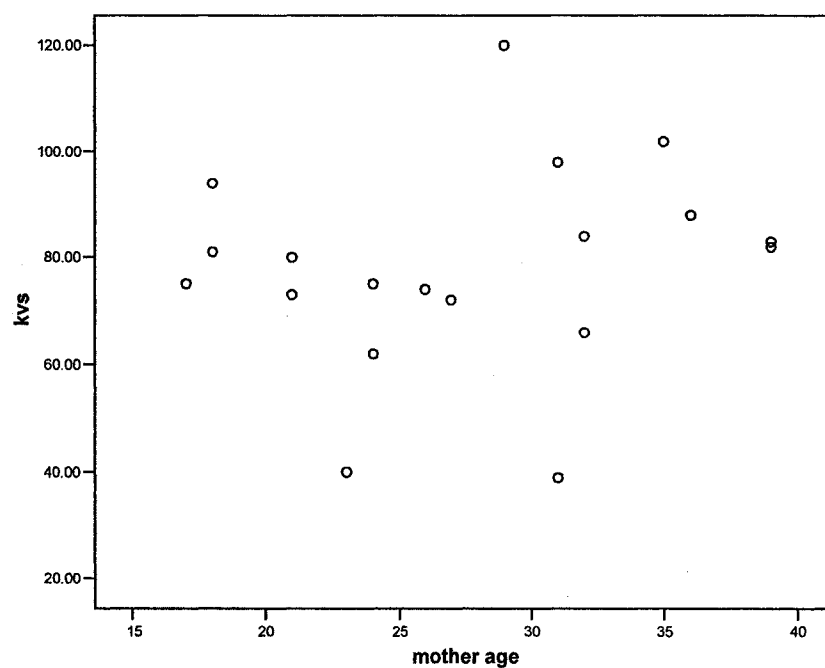


Figure 10. Scatter plot of KVS vs. mother's age.

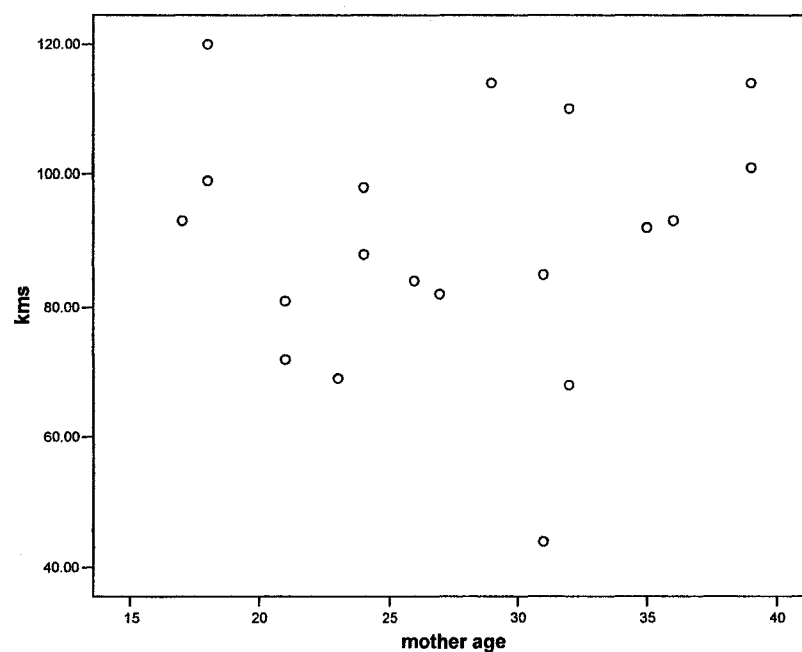


Figure 11. Scatter plot of KMS vs. mother's age.

Hypothesis 4.

To test the effect that FAS has on American Indian children's fluid and crystallized intelligence performance, a MANOVA was conducted to detect differences across FAS groups. When using MANOVA all six scores yielded no observations. So the test scores were combined which resulted in differences across FAS groups on the KVS combined with the KMS only ($p = .01$) for each of the MANOVA test statistics (i.e. Pillai's Trace, Wilk's Lambda, Hotelling's Trace, and Roy's Largest Root.). A one-way ANOVA was used with each of the six intelligence measures in order to determine if any of such measures differ across the categories of FAS and Non-FAS children. Tukey's multiple comparisons were used to find out where the differences exist when an ANOVA test was significant. All tests were based on the .05 testing level (see Table 28).

Three of the six ANOVA tests are significant at the .05 testing level: the KVS, WASI-VIQ, and WASI-PIQ. Two of the other measures approached the significance level: PPVT-R ($p = .077$), and KMS ($p = .055$), indicating the trend of difference (see Table 28).

Table 28.

Descriptive statistics of intelligence measures for AI children by FAS status.

Intelligence Measure	FAS Status	N	Mean	Standard Deviation	F	Sig.
PPVT	FAS	30	75.70	18.93	2.620	.077
	Not FAS	92	83.20	14.63		
	Deferred	15	81.33	13.71		
Raven	FAS	18	92.78	12.44	.108	.898
	Not FAS	48	93.44	11.50		
	Deferred	15	94.60	9.28		
KVS	FAS	30	79.30	16.83	8.076	.000
	Not FAS	231	88.11	12.02		
	Deferred	19	81.74	12.00		
KMS	FAS	30	88.80	16.23	2.930	.055
	Not FAS	229	95.24	13.51		
	Deferred	19	94.26	11.61		
WASIVIQ	FAS	20	76.60	12.51	7.141	.001
	Not FAS	96	87.90	12.07		
	Deferred	6	85.67	12.60		
WASIQ	FAS	20	83.95	15.80	3.751	.026
	Not FAS	96	92.80	11.69		
	Deferred	6	92.50	24.42		

The Tukey tests for Kaufman verbal scale subtest scores (KVS), WASI-Verbal scale subtest scores (WASI-VIQ) and WASI Performance scale subtest scores (WASI-PIQ) show that all the differences lie between those with FAS and those without FAS. The results show that the American Indian children with FAS scored significantly lower in KVS, WASI-VIQ and WASI-PIQ measures than those children without FAS (see Table 29). On average, the children with FAS scored lower than about two thirds (0.68) of the standard deviation in KVS than those without FAS; the children with FAS scored about one (0.88) standard deviation lower on the WASI-VIQ than those without FAS; and the children with FAS scored about two thirds (0.69) of a standard deviation lower on the WASI-PIQ than those without FAS.

Table 29.

Significant pair-wise comparisons from the Tukey tests.

Intelligence Measure	Pair of Comparison	Mean Difference	95% CI of difference	Pooled Std. Dev.	Effect Size (d)	Sig.
KVS	Non FAS FAS	-8.81	(-14.58, -3.04)	12.94	- 0.68	0.001
WASIVIQ	Non -FAS FAS	-11.30	(-18.39, -4.20)	12.83	- 0.88	0.001
WASIPIQ	Non-FAS FAS	-8.85	(-16.55, -1.16)	12.86	- 0.69	0.020

In the final analysis, only those children who were diagnosed with FAS were included. Paired *t*-tests were used to detect the differences between KVS and KMS

scores, as well as between WASI-VIQ and WASI-PIQ scores. The analysis found that for the American Indian children with FAS, their Kaufman Verbal subtest scores (Gc) are significantly lower than their Kaufman Matrices subtest scores (Gf). Also, their WASI Verbal subtest (Gc) scores are significantly lower than their WASI Performance subtest scores (Gf). Such results are consistent with what was found in Hypothesis 1, where all sampled children were included, regardless of FAS status. Table 30 presents the descriptive statistics of the four intelligence measures for the children with FAS, and Table 31 presents the results of the paired *t*-tests.

Table 30.

Descriptive statistics of intelligence measures for American Indian children with diagnosed with FAS.

Intelligence Measure	<i>N</i>	Mean	Std. Dev.
KVS	30	79.30	16.83
KMS	30	88.80	16.23
WASI-VIQ	20	76.60	12.51
WASI-PIQ	20	83.95	15.80

Table 31.

Paired t-tests for intelligence measures for American Indian children with FAS.

Pair of Comparison	<i>N</i>	Mean Difference	95% CI of Difference	<i>t</i>	Sig.
KVS – KMS	30	- 9.50	(-14.53, -4.47)	-3.862	0.001
WASIVIQ – WASIPIQ	20	- 7.35	(-14.45, -0.25)	-2.167	0.043

Also, supplementary multivariate regression analyses with mother's age, mother's education, child's age, child's gender, and SES as predictors in a multinomial regression model for each IQ score resulted in the sample sizes becoming smaller for each dependant variable and none of the independent variables tested were significant. A possible reason for such finding is due to the fact when there are multiple predictors in the model, sample sizes decrease. A possible limitation of this study is that small sample sizes restrict the analysis at the univariate level, and is an area for future research with a larger sample size.

Chapter 4

Discussion and Conclusions

Overview

This study employed data of children and mothers from a Fetal Alcohol Syndrome (FAS) epidemiology study among Plains Indian Tribes. This provided a unique opportunity to examine empirical evidence of fluid intelligence (Gf) and crystallized intelligence (Gc) for Plains Indian children, an area of research that has not been previously investigated. To date, studies of observed differences among ethnic groups on global ability measures, such as fluid and crystallized intelligence measure, is sparse. While fluid and crystallized intelligence as a developmentally and possibly culturally relevant factor is understudied in general, studies of intelligence patterns in American Indian child samples have not appeared in the literature.

This study also proposed to determine the contributions of maternal education to children's crystallized abilities. A weakness of this area of study is the absence of tests of the fluid abilities of the mother. With this having been said, this study will contribute to the literature on the combination of constitutional and environmental factors which result in a stronger mother-child crystallized intelligence correlation. One might say that the need for comparing actual maternal measures with those of offspring becomes obvious from the methods used in this study. Studies of group difference on tests of fluid and crystallized intelligence are rare for children and even more so for minority children. An examination of the utility of specific tests, subtests, and instruments in the evaluation of Plains Indian children by this study will contribute to the extant literature on this topic. Thereby, this study contributes to exploring ways to assessing differing intellectual

abilities and encouraging educational pluralism to meet the educational needs of different groups of society. Understanding such pluralism might maximize educational attainment by differential approaches to achievement through various approaches utilizing fluid and crystallized abilities.

Finally, the effect of prenatal alcohol exposure and its effect on these children's fluid and crystallized abilities were examined. It is intended to help inform a greater understanding of the cognitive strengths and challenges of this cohort of children. In turn, this could help inform school and treatment practices on strategies to address the needs of fetal alcohol effected children.

Crystallized versus Fluid Intelligence for American Indians

Within the limits of the measures used and the age range sampled, the results of this study provide tentative answers to the questions raised at the beginning. On average, Plains Indian children obtained significantly higher mean scores on measures of fluid ability as compared to their mean scores on measures of crystallized ability. And that mother's education will correlate positively with the child's performance on crystallized test performance, but the support for this effect was weak.

The significant difference between test scores of fluid intelligence measures and crystallized intelligence measures in American Indian children in this study leads the way to a discussion of the establishment of a theory of intelligence that spans the range of cultures. Overall, the American Indian children performed better on the WASI performance scale and the K-BIT matrices scale, both assessments of fluid intelligence, indicating a stronger ability in physiological neurological functioning which is manifested in relation perception and performance in new situations.

This finding supports the Gf-Gc theory and remains as a useful, broad characterization of distinct types of cognitive abilities. Given the premise that crystallized abilities are most affected by societal exposure, acculturation, educational opportunities and benefits derived from higher socioeconomic status, the significant difference on fluid abilities of American Indian children is revealing. The 7 to 9 point performance difference on both measures of fluid intelligence, WASI performance scale and K-BIT matrices scale, respectively, speaks to the cognitive strengths of American Indian children. For these children, as with more recent studies of profile differences, American Indians are stronger in visual reasoning than in verbal reasoning skills (McShane & Cook, 1985; McShane & Plas, 1982; Suzuki & Gutkin 1993; Taylor & Richards, 1991). This finding also suggests that measures of fluid intelligence are a better index of intelligence of Indian children. American Indian children have a visual style of learning and fluid intelligence measures can be used to evaluate the cognitive skills of American Indian children, since their visual-spatial abilities (fluid abilities) are, on average, better developed than their crystallized abilities.

It has been a criticism that widely used measures of intelligence for children disproportionately assess crystallized skills and domains of intelligence associated with opportunity for learning (Woodcock, 1990). Woodcock (1990) and McGrew (1997) have shown that approximately one-third of the batteries' subtests measure crystallized skills and an additional quarter focus on quantitative knowledge and reading/writing skills that directly assess instruction and opportunity for learning; crystallized skills broadly defined. Only 7% of subtests directly assess fluid skills and another 10 % assess processes and memory skills that have a fluid intelligence component.

Given that commonly used measures of intelligence disproportionately assess crystallized intelligence, testing by these measures must be seen to be somewhat dependent upon opportunity and availability of experience. The poor representation of fluid abilities on current intelligence batteries for children would seem to be particularly disadvantageous for children from chaotic homes, disadvantaged homes, and, according to the findings in this study, more specifically American Indian children. Currently, available common measures of intelligence would provide a limited perspective on the cognitive abilities of American Indian children facing constraints on opportunity for the types of crystallized skills stimulated by mainstream and affluent environments. The paucity of fluid measures of intelligence commonly used raises concerns for American Indian children. Valencia and Suzuki (1997) have suggested that racial-ethnic populations less familiar with mainstream American culture may be at a disadvantage on traditional intelligence measures. This continues to be the case for American Indians in general, who have a mean IQ score at approximately 90 with a verbal IQ of 83 and a Performance IQ score of 100 (Vraniak, 1994).

Clinical and developmental neuroscience investigations of the functioning of the prefrontal cortex have found that cognitive processes that are to be frontally mediated, such as working memory, the regulation of attention, and planning and problem solving, are all fluid skills broadly defined and have been shown to be strongly related to performance on currently existing measures of intelligence. Linking executive cognitive abilities of the prefrontal cortex to fluid intelligence have previously been taken as an indication that working memory ability is essentially Spearman's "g" This interpretation

reflects Catell and Horn's theory that Gf would be a precursor to Gc, as fluid skills would facilitate and enhance the acquisition of crystallized knowledge.

Special Education versus Gifted and Talented Placements

As aforementioned, the heavy reliance on Gc performance in widely used measures of intelligence for children disproportionately assess as crystallized and domains of intelligence associated with opportunity for learning (Woodcock, 1990). For Indian children, the under representation of fluid abilities on currently available measures may be contributing to the relatively high placements of minority children in special education and the relatively low placements in gifted-and-talented programs. The roles intelligence tests play in placements continue to be of concern to many minority groups. The Committee on Minority Representation in Special Education (National Research Council) report that in Montana, local agencies report all disabilities each student is considered to have; and the state education agency, in turn, assigns a single federal disability to categorize each child, contributing to a skewed representation of Indian children in special education who are culturally and linguistically different. In 1993, the learning disability odds ratio for American Indian/Alaskan Native children was 1:24, revealing that they have a 24 percent greater likelihood of being assigned to learning disabled categories than do Caucasians. Additionally, the overall under representation of racial/ethnic minority groups among top students relative to the white majority is extensive and long-standing. Additionally the representation of minority scores included among top students using all traditional measures including intelligence scores is severely lacking. Extensive under representation is present at all levels of the educational system, beginning in kindergarten and the limited presence of several minority groups among

high-achieving students indicated by substantial minority-majority achievement gaps existent at all social class levels as measured by parent education and family income (National Research Council, 2002). For American Indian children, the various established and commonly used measures of intelligence need to be validated with an intricate examination of the empirical evidence of the difference in cognitive styles, specifically fluid intelligence.

The importance of this hypothesis rests on the belief that intelligence should not be considered merely a trait of individuals. Rather, intelligence is best conceived as the product of a dynamic process involving individual experience, competencies, and the values and opportunities afforded by society. For Indian children, all definitions of intelligence are shaped by the time, place, and culture in which they evolve. Although the definitions may vary across societies, the dynamics behind them are influenced by the same matrix of forces: the domains of knowledge necessary for survival of the culture, the values embedded in the culture (such as respect for elders) social norms, rules of ceremony, and the educational system that instructs and nurtures an individual's competencies.

The fact that the American Indian children did better on measures of fluid intelligence is reflected in the culture and the research on multiple intelligences, wisdom and Erickson theory of personality development. Erickson's model (1986) is an antecedent of the wisdom and multiple intelligence theories; personality characteristics are specific to the domain of the fundamental pragmatics of life and not be primarily reflective of general adaptive functioning. The positive relationship between personal growth and wisdom-related performance can be taken as empirical evidence supporting

models of personality development such as Erickson's. In his theory Erickson clearly relates the notion of wisdom with the maturation of character. For American Indian children, their inclusion in all aspects of the culture and their awareness of the wisdom of elders in regards to social roles and responsibilities continues to be dismissed in the school environment.

The research on multiple intelligence and wisdom refers to the predictive power of psychological-mindedness reflecting the degree to which an individual is interested in, and responsive to, the inner needs, motives, and experiences of others. According the research on academic performance of American Indian children (Dauphinais & King, 1992; Foerster & Little Soldier, 1974; Zintz, 1962) American Indian people share some "core" values that differ from the dominant culture in the educational system. For example, in Native American cultures a) children are treated with the same amount of respect as adults; b) there is a strong belief in the importance of cooperation and harmony; c) it is more admirable for a person to contribute to the well-being of the group rather than individual achievements; d) competition is valued, but in the intra-individual sense; e) the focus of living is in the present-time; f) in general, children are not accustomed to the structure implemented by adults, especially as it exists in the school setting; and g) there is a high worth associated with the traditional lifestyles and culture. Therefore, psychological-mindedness appears to be intrinsic in the culture of the American Indian, a factor in a multifactor theory of intelligence, and evident in fluid intelligence but significantly lacking in the general school system and assessment process.

Mother's Ability Reflecting on the Child's

One prediction in this study was that mother's education would positively correlate with the child's performance on measures of crystallized intelligence. This hypothesis was not supported by the linear regression analysis conducted. Crystallized abilities are most affected by societal exposure, acculturation, educational opportunities and benefits derived from higher socioeconomic status; hence the prediction was that a positive correlation between mother and child's crystallized scores would be found. Previous research has suggested that crystallized intelligence might have greater heritability than fluid abilities (Defries, Kuse, & Vandenberg, 1979; Plomin, Defries, & McClearn, 1980). Horn, (1985, 1991) has concluded that there is reason to suspect that fluid intelligence is as influenced by learning as crystallized intelligence and that crystallized intelligence might be inherited to at least the same degree as fluid intelligence. The design of the present study did not allow a comparison of the relationships between mother/child measures of fluid intelligence and crystallized intelligence. Based on extant research, crystallized intelligence would be held more in common across mother-child pairs. Previous research has shown that fluid intelligence abilities would be more unique to each individual in the mother-child pairs. This study attempted to add support to the theory that crystallized abilities are not only culturally bound, but possibly as inherited as fluid abilities. Additionally a more individualized testing of mother's crystallized abilities such as intelligence testing might have correlated positively with the children's crystallized abilities. These are weaknesses of this study and areas for future research.

Maternal Age as an Influence on Intelligence

Maternal age at the birth of the child was predicted to have a significant effect on the child's performance on measures of Gf and Gc. It was hypothesized that the older the maternal age, the more negative effect on the child's Gf/Gc intelligence. ANOVAs and linear regressions on mother's age and child measures of crystallized and fluid intelligence showed no significant effect for maternal age. This prediction was based on the literature and did not prove to be significant in this study. Also, because maternal health variables are among the most common and consistent risk factors for FAS and related problems (i.e. advancing age of the mother, older than 25 years of age, three or more children, co-use of tobacco and other drugs; NIAAA, 2000), it was anticipated that performance on measures of Gf and Gc would highly correlate with mother's age and FAS diagnosis. This finding was not significant, which appeared to be due to the smaller sample size.

FAS and Intelligence Among Plains Indian Children

Previous studies of the cognitive problems associated with prenatal alcohol exposure have identified higher order cognitive difficulties. The present study attempted to advance an understanding of Gf and Gc deficits seen in children with FAS. As predicted, the children diagnosed with FAS exhibited significantly more difficulty on both measures of crystallized and fluid abilities.

Significant differences at the .05 level were found on scores of the K-BIT verbal scale, the WASI verbal scale, and the WASI performance scale when the data included three groups in the analysis (FAS, deferred, and not FAS). The PPVT-R and K-BIT

matrices scale also approached significance in this comparison indicating a trend of difference. American Indian children with prenatal alcohol exposure and symptoms of FAS showed greater deficits on all measures except for the Raven's Progressive Matrices.

Additionally, there were significant group differences between children with FAS and children without FAS on measures of Gf and Gc, indicating that children with FAS have a range of cognitive difficulties including attention, language, executive processing, learning ability, and mental computation, for example.

While in general the children with FAS followed the performance profile of the American Indian children on measures of Gf and Gc, with better performance on measures of Gf. It should be noted that their performance on the Raven's Progressive Matrices was not significantly impaired as compared to children without FAS. This is in direct contradiction to the previous research by Kodituwakku, Kalberg, Robinson, and May (2003) which found that native children with FAS earned 1 standard deviation below that of the native children without FAS. But there is a difference in the comparison samples. In this study the "not FAS" children were not controls in that they were neither free of prenatal alcohol exposure nor learning problems as in Kodituwakku et al. (2003). The "not FAS" groups in this study were children referred to diagnostic clinics because of suspected prenatal exposure or because of behavioral or developmental problems. Therefore, while the overall results of this dissertation suggests that the fluid abilities that include a more complex executive control processes and domain-independent associative process are not affected to the extent as previous studies have suggested, it is likely not true. The findings suggest that both groups of children were equally affected by alcohol

exposure or the environment in a manner that suppressed statistically significant differences on the Raven. Furthermore, small sample size could impact these results; replication of this study with a larger sample size and control subjects who are neither alcohol exposed nor have behavioral problems is warranted to validate these findings in this limited researched area.

Further Issues, Implications and Conclusions

When tested for intelligence, American Indian children have demonstrated a pattern of performance that differs from the national norms. It is crucial that these findings be accurately understood, because psychoeducational assessment frequently determines placement and access to educational resources. The American Indian child continues to be placed in special education programs while being “overlooked” for gifted programs.

This study generated some interesting and heuristic findings. However, design limitations should be noted. The findings were based on previously gathered data from a larger epidemiological study on the prevalence of Fetal Alcohol Syndrome in American Indian children. A study designed with a control group not referred to developmental clinics might be utilized to investigate the differences on crystallized intelligence and fluid intelligence and the effect of Fetal Alcohol Syndrome.

This study substantiates the need for intellectual assessment to address the unique cognitive style of American Indians. The theory of crystallized intelligence and fluid intelligence and the applicability to ethnicity is not a factor in assessment for learning disabilities or giftedness. Currently only 38 state policies make some reference to issues of identifying gifted students from “culturally diverse populations, economically

disadvantaged students and disable students” (National Research Council, p.276). In some states, there are specific guidelines for selecting tests or carrying out the identification process to help schools identify greater numbers of gifted minority students. Other states have recommended specific instruments such as the Raven’s Progressive Matrices Test, the Matrix Analogies Test, and/or the Torrance Test of Creative Thinking. These tests are reported to emphasize reasoning or fluid intelligence and de-emphasize information acquisition or crystallized intelligence. The Raven’s Progressive Matrices has been viewed as desirable due to the cultural neutrality of the abstract patterns.

An important, but poorly understood finding, regards the distinct cognitive style of American Indian children. For centuries, Indian people depended heavily on visual sensory/perceptual pathways. They followed animals by sign and track and memorized visual aspects of their territory. The women were able to single out by sight edible plants from a mass of vegetation. Predictions of weather changes and the migration of animals based on tribal survival were made by studying the visual aspects of their environment. The principle of visual observation was central in the culture.

Additionally, American Indian children’s representation function seems to be mediated visually rather than linguistically, and they do not spontaneously analyze their experience in verbal terms, but, rather as a whole (Tharp, 1994). A review of the literature reveals near total consistency in available research: Indian children are most successful at processing visual information (Valencia & Suzuki, 1997). Relatively high visuo-spatial ability in American Indian children has been attributed to a functional adaptation to the demands of an environment in which perceptual-motor skills are highly

useful and valued. This visual proclivity supports the holistic (versus analytic cognitive) style that is characteristic of American Indians. Perceptual, cognitive, neurological, semiotic, sociological and interpersonal dimensions are each aspects of a relational whole, and American Indian children experience and process these dimensions as inseparable and interacting aspects of the same unity. This is a cognitive style that appears to be heavily influenced by fluid intelligence.

The apparent measurement need of fluid intelligence for assessment and school placement would seem all the more pressing given evidence for the relation of fluid cognitive skills to child development, and minority populations. However, widely used measures of intelligence for children continue to disproportionately assess crystallized skills and domains of intelligence associated with opportunity for learning. Both historically and presently this measurement strategy is a disadvantage for the American Indian child.

Whether through the facilitation of the acquisition of crystallized skills, as proposed by Cattell and Horn(1978), or as a separate insoluble influence on academic achievement, fluid skills play a clear role in intelligence, and academic achievement in childhood development. Continuing attention to the measurement of fluid intelligence in the cognitive function of American Indian children should prove particularly valuable for educational and social policy decision-making. This is particularly true for children facing psychosocial disadvantage, such as many American Indian children living in impoverished communities. Perspectives on the development of intelligence and its relationship to academic achievement that conflate fluid and crystallized intelligence is particularly disadvantageous for children. In particular, children who have difficulty in

learning and are tested with measures that conflate fluid and crystallized intelligence does not differentiate whether a child may have limited opportunity to acquire the types of knowledge assessed by measures of crystallized intelligence or difficulty with the fluid skills that promote learning. With the current policy of “No child left behind,” the Indian child continues to be left behind due to the increasing emphasis on accountability in education and on the need to ensure that American Indian children acquire the crystallized skills that education provides. In contrast, the application of knowledge about fluid intelligence with American Indian children and the vital role it plays in learning and development is currently inadequate. Fluid intelligence may be the basis of knowledge acquisition and necessary for crystallized knowledge acquisition, but continues to be systematically and politically overlooked, hence contributing to the American Indian child being “left behind”. Future research and educational policy that is grounded in the developmental and cultural utility theory of a holistic person-oriented approach to education and assessment may herald some tangible scientific and valid progress in the study of cognitive development and the resource of culture and ethnicity in child development and learning.

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